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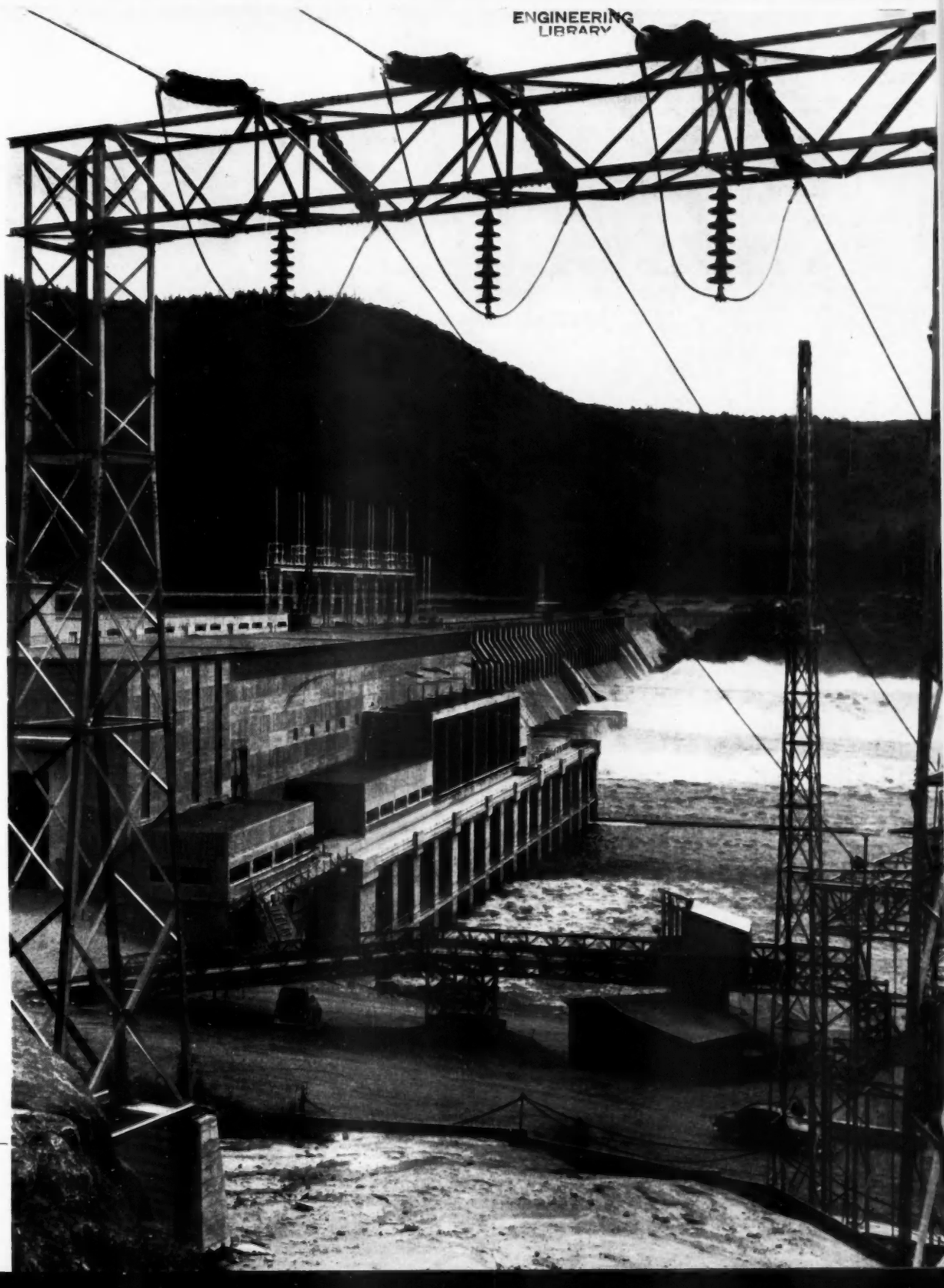

this issue

THE ENGINEERING INDUSTRIES: WHAT THE FUTURE HOLDS

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ENGINEERING

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A Time for Faith

IN presenting this 92-year-old journal with some fresh developments in its design, we are engaging in a typically engineering activity. Every engineering design must sooner or later be refined and improved, or it will be thrown on the scrap heap. Each stage of development must be based on an unceasing concern for the requirements and interests of the user, and on a readiness to apply the techniques and knowledge which science daily throws up. These present changes are founded on a study of that kind. We hope you like them. They were detailed in our issue of December 6, and now that the product is in your hands there is no need to describe them here, except to add that we are now giving the names of the chairman and executive staff, on the last editorial page.

Of greater interest to-day, perhaps, is a fundamental problem which we were driven to consider in relation to these improvements in the journal. This problem is revealed by the self-examination, the questioning of motives and purposes, the search for precedents and authorities, which characterise the industrial nations at the turn of the year. True to their colours, thinking people of the United States are showing a degree of discontent with themselves and their society which is remarkable for a nation which has long led the world in spirited endeavour. Russian surprises have sparked off this questioning, but it had to come; the idea that the sole purpose of life and work is, to use the language of the advertisements, the attainment of "gracious living," could not be sustained indefinitely while no one faced up to the difficulty of defining "grace." If gracious living simply meant bigger and better automobiles—and more of them per family—it was likely to be singularly lacking in grace. Or if gracious living meant living in conformity with the norm of the "organisation man," achieving a kind of human fitness for purpose, giving service and no offence, it seemed to lead to the very opposite of what we claim for our democracies. The individual was not individualistic but rather a unit of society, moulded and conditioned more than ever by his environment and by the resultants of innumerable forces over which he had no control.

In Britain the impact of recent events has not been so great. We have known for a generation and more that we cannot hope to do all things better than everyone else all the time. We can, and do, achieve supremacy here and there, and from time to time—that is all that any industrial nation can reasonably expect in this age. Yet we, too, have not resolved the fundamental issues which science and engineering have raised. In our case this lack of resolution springs from a different cause—from the fact that we have still not developed a whole view of the arts, humanities, science and engineering. We put each of them in watertight compartments because then it is easier to ignore those which we do not understand or appreciate.

Who, then, can show us a whole view? One of the few who can is a doctor, not of science or engineering, but of divinity. The Rev. Alan Richardson is professor of christian theology at the University of Nottingham, but his understanding of science and engineering in relation to all knowledge is more thorough than most of us could attain. In a lively booklet he has written for the S.C.M. Press, *Science and Existence*, he says that "natural science and its offspring, technology, are the two blessings of Christian civilisation which the whole world, east as well as west, is willing to accept." The Christian view of the world, he argues, was a necessary precondition of the emergence of science in the last few centuries. He does not pursue this interesting proposition, but it is clear that without that conception of the individual serving others which religion, and particularly the Christian religion, fostered, science and engineering could not have happened.

The danger facing us now, Professor Richardson believes, is "that those brought up in a scientific civilisation will never develop their historical and poetical imagination because they are entirely absorbed in the vast and complicated world of scientific truth, which indeed is so fascinating and absorbing as to engage their whole energy and interest." And unless we develop our "historical and poetical imagination" we cut ourselves off from all that knowledge which is not wholly scientific—a loss which in fact we could not survive because we depend more than we often realise on the "existential" knowledge of centuries of civilisation. Indeed we can turn to it for the answer to the question posed earlier. In Professor Richardson's words: "it may be that modern science and technology are the fulfilment of the divine promise and commission that man should have dominion over the earth." The deep insight of the writer of the first chapter of Genesis, he says, may prove to be nearer the mark than those who think science is the means by which civilisation is destined to destroy itself. That is the kind of faith we need to-day.

Cover Picture. *The generation and transmission of electric power call for a contribution by every type of engineer: civil, mechanical and electrical. Particularly is this so of hydro-electric power. The Otto Holden hydro-electric station on the Ottawa River, Canada, shown in the cover picture has a dependable capacity of* 282,000 *h.p.*

* * *

Plain Words

Only the very young or the very hopeful can to-day look far into the future without anxiety. It is not merely that we are always conscious of the fatal error which someone, sometime, must inevitably make; we have almost reached the stage of welcoming that cataclysm as a release, an opportunity to begin again, as a man burdened with too much property half hopes for a fire. Much more, we have come to fear the technocratic tyranny to which Mr. Aldous Huxley, George Orwell and their followers have destined us. We view with horror the inhuman systematic world which has been depicted as the logical consequence of scientific reverence, and feel ourselves trapped in a machine, already in motion, over which we have no control.

Problems of control lie at the centre of our dilemma. The interwoven fabric of our society has become so complex that no single mind can grasp its pattern or significance; it is like an organic monster acting without consideration for its parts, and quite indifferent to their separate purposes. Denuding the earth of its resources, growing at an unbelievable rate, unconscious of its self-destructive powers, it spreads like some diseased creation of scientific fiction. Or, it is like a machine with too many dials in the cockpit. No-one can assimilate all the necessary data to maintain control, and feedback has become too feebly attenuated for satisfactory self-adjustment.

One prescription—almost as distasteful as the complaint itself—is a deliberate simplification of the data by enforcing an overall conformity. This approach, which the novelists have envisaged as the outcome of our present situation and of tendencies already apparant, is by no means as inescapable as they suggest. At present no human brain can accommodate all the data necessary to reach a political conclusion, so that instead we resort to political opinions. One day, we may, with the aid of computers, be able to demonstrate that the election promises of any one politician are mutually incompatible. The next step will be to determine which of our manifold desires—placed, of course, in order of preference at the polling station—have the highest coefficient of congruity, so that eventually we shall be able to dispense with politicians entirely.

Life under a benevolent computership may prove quite as tiresome as it is to-day, but as we have managed to retain our sense of proportion for at least two millenia (with the help of Aristophanes and Mr. Groucho Marx) we may well continue to do so. The means are to hand for ruling our environment; by using them we may prevent our environment from ruling us.

CAPRICORN

Weekly Survey

Ideas are the Cheapest Capital

At the British Association meeting in August, Professor Blackett suggested that " in addition to likely commercial and government short-term lending, an additional £1,000 million a year is needed as a free gift or as long-term loans from the 400 million rich Westerners to the 1,000 million Asians, Africans and South Americans in the under-developed countries outside the Soviet orbit." The British share of this gratuity was to be £150 million a year. In the December issue of the *Three Banks Review* Professor Cairncross takes the view that it would be unwise to start setting aside any fixed annual contribution from the industrial nations without any relation to what the under-developed countries can absorb.

The only existing agency that could handle long-term loans and grants is the International Bank for Reconstruction and Development. This body dislikes what it calls " fuzzy " loans, and prefers making loans that borrowing countries can repay at current rates of interest. But the Bank has been lending no more than £250 million a year, which is barely a quarter of the target proposed by Professor Blackett. The handling of commercial and non-commercial loans in one agency creates great difficulties. Unless it has been clearly laid down that non-commercial loans could be made only for a clearly defined list of purposes, it is not easy to see how the Bank could stop short of taking over responsibility for all international capital transactions with the countries concerned.

The mere providing of capital for under-developed countries is only one part of the problem. At least as much depends on the spread of knowledge and know-how. A modest expenditure on technical expertise may offer returns without additional capital, that far exceed what other forms of expenditure might bring. " Borrowed ideas are the cheapest capital " whether part of the technical assistance of the West or of Soviet aid for China. The handing out of large capital sums, far from providing a short cut to development, may, unless properly handled, saturate the economy and in fact slow down the rate of progress.

Data Processing for Managers

The British Institute of Management have issued advance information concerning a course on management in the light of automatic data processing, lasting five days from January 20. It was organised with their full support to enable British managers " to take advantage of American automation experience in the use of electronic computers in the processing of data for industry." People who pay their 85 guineas will hear a team of experts from the John Diebold and Associates organisation give lectures based on the study and experience of 1,000 computer organisations in the United States. The whole thing will be highly practical: how to introduce automatic data processing (ADP), how to manage and conduct a system study, how to match the system with available equipment, how to staff and to train staff, how to provide " ADP orientation " for management and for the entire organisation. Finally there will be a summary placing ADP in its full industrial context.

John Diebold is a young man of 31 who has been called " the elder statesman of automation." Six years ago he published the first book to forecast the social and economic consequences of automation. Since then he has built up America's largest consulting firm specialising in automatic data processing and has advised practically every industry on the scope existing for automatic methods and on the installation and operation of ADP. He has paid a great deal of attention to the management and training of personnel and to the full implications of the change in terms of human relations.

Experience of this kind is valuable and, to quote the B.I.M., the purpose of the course is primarily to give British managers " an opportunity of learning from the mistakes of others and of equipping themselves to avoid errors which have cost American firms so dearly." Mr. Diebold has written, for ENGINEERING, a special review of automatic data processing, which we will publish shortly.

Technical Ambassador

The decision of the Indian Government to standardise on 50-cycle single-phase systems at 25 kV for main-line electrification has given the French an opportunity which they were quick to seize. It was reported last summer that extensive conversions were contemplated in the Bengal, Bihar, Bombay and Madras areas as well as large new electrification projects. The performance of the extensive 50-cycle electrifications on the French Railways impressed the Indians and they decided to ask S.N.C.F. to provide technical assistance.

The interest in this lies in the sponsorship by a government in the Western Hemisphere of what is tantamount to an organisation for the promotion of exports. In the provision of technical assistance, which will include the planning of projects, the drawing up of specifications, negotiation with and choice of contractors and the supervision of the work, the S.N.C.F. will have the assistance of Sofrerail (Societe Francaise d'Etudes et de Realisations Ferroviares). That company is headed by M. Armand Porchez, who is assistant director-general of the S.N.C.F. and its aim is to foster the use of French railway techniques in other countries. Sofrerail will have staff in India for a year after the completion of each project, alongside personnel from the S.N.C.F., who also undertake to train Indian staff in their engineering departments and in their own electrified networks. A recent article in the *Railway Gazette* pointed out that the president of the French Railways, M. Louis Armand, played a leading part in bringing about " an arrangement advantageous not only for French industry but for French prestige."

The British and other Western European governments would be well advised to think along similar lines. In this country, where builders of rolling stock are dependent on export markets for the bulk of their sales, action of this kind was left to the industry. The Locomotive Manufacturers' Association assisted the Indian Government to set up locomotive workshops very successfully over the past few years. It was the prices quoted by foreign builders—in some cases ridiculously below costs—and the scarcity of Sterling, which led to the loss of the Indian market. France has yet to experience the full blast of competition from Japan, which also enjoys a home market in industrial frequency electrification. The Japanese are quoting and will be hard to exclude. But the force behind Sofrerail, and the initiative that led to its formation, are both a lead and a symptom. There are few other ways left to bid for the political allegiance and clientele of under-developed countries.

Figures for Free Trade

Companies interested in the likely impact upon themselves of a free market in western Europe have been handicapped by the absence of adequate statistics. Information on trade between the countries concerned was not only incomplete but scattered in various publications and rarely

comparable. To secure a reliable guide in respect of any particular group of products was a major undertaking. O.E.E.C. have just published a statistical volume under the title *The Network of Intra-European Trade—Trade by Product in* 1956, which goes a long way towards providing what was needed.

In a short introduction—the rest consists entirely of statistical tables—the authors point out that the progress made towards the establishment of the European Economic Community ("Common Market") and the negotiations for a Free Trade Area have brought problems of intra-European trade into the forefront of present-day economic thinking. "The need was felt" they say, "for a working instrument that would bring together the available data in as handy and complete a form as possible." This they have achieved to a surprising degree. Their "working instrument" shows in considerable detail the state in 1956 of the international market which the projected Free Trade Area would embrace.

One table is devoted to each group of products and each of the main items in the Standard International Trade Classification. Each table shows, in quantity (metric tons) and value (United States dols.), the whole network of trade between the individual O.E.E.C. countries, the six Common Market countries and the O.E.E.C. countries as a whole (together forming the projected Free Trade Area).

Commodities are well sub-divided. Trade in iron and steel products is shown under 11 separate headings, such as ferro-alloys, drop and strip, steel tubes and fittings, and trade in engineering products under 14 headings, covering 17 large format pages. Taking metal-working machine tools as an example, trade between O.E.E.C. countries totals nearly 103 million dols. of which Western Germany accounts for 81 million, Switzerland 33 million and the United Kingdom 13 million. This is useful basic information; the picture it reveals of Britain's trading position is certainly no cause for complacency.

U.S. Tariff Policy

The Commerce Department of the United States Administration is proposing to extend the United States Reciprocal Trade Agreements Act for a five-year period. In addition, the President is to ask Congress in January for authority to reduce duties by 25 per cent. over the next five years. It is thought that the last request is to give the Administration sufficient flexibility to negotiate tariff arrangements with the European Economic Community (which will consist of the members of the European Common Market) in due course. Authority is also being sought to increase tariffs steeply but it is being explained away as a tactical manoeuvre to reduce opposition in Congress.

The tariff policy of the Administration is still mainly liberal. On the other hand, Congress is becoming increasingly protection-minded. Some of the Democrats are siding with the Republicans, who are the traditional tariff party on this issue and a bitter struggle is expected at the beginning of 1958 on the tariff issue.

It will be no easy task to reduce hostility to tariff disarmament while a business recession is in progress in America. Few politicians have improved their standing with the electorate in the United States by pleading for freer trade when business in the home market has been falling off. Among the most urgent specific problems of tariffs are wool textiles, which are of no direct interest to the engineering industry, but the efforts to replace barter agreements by sliding tariffs on lead and zinc are of more direct concern.

Life will be made more difficult for the British exporter if the Administration's policy fails, for the dollar market is becoming increasingly important and will be difficult enough to hold as activity slackens off in the United States this winter without the additional obstacle of higher tariffs. The "two-way option" sought by the Administration could lead to just that.

No General Fair

British industry does not support general fairs. The failure of the B.I.F., first in London, then in Birmingham, showed that a national trade fair of a general nature could not command enough support. The Birmingham Chamber of Commerce, who were responsible for last year's B.I.F., asked the Government to go into the question of an international fair.

The Federation of British Industries sounded industrial opinion on the subject of general fairs and found the vast majority opposed to them. Of the 109 trade associations whose members are concerned with trade fairs, some 105 favoured specialised fairs and only two showed any decided preference for general fairs. Against this there is the experience of other countries, and particularly the United States, where the international New York fair has been a tremendous success. There is little doubt that an international fair would be well patronised in Britain also, especially in view of the wide interest which exists in the possibility of a Free Trade Area. But the support would be foreign rather than British. The unwieldy character and lack of sparkle of the B.I.F. during the past few years has set industrial opinion against this type of fair. On the other hand it is felt that there are too many specialised fairs—some sixty are held each year—and that the overlap between a number of them is too large. The F.B.I. found some support, therefore, for widening the scope of specialised fairs sufficiently to allow for the grouping of the products of allied industries.

The Board of Trade must now consider whether or not to abide by the F.B.I. findings. Increasingly during the next decade the countries of the western hemisphere will be forced into sponsorship and support of national trade movements to strengthen their competitive position *vis-à-vis* the East. About half the organisations consulted were against having specialised fairs open to foreign competitors. The F.B.I. will now conduct another inquiry to ascertain "what is required in order to give specialised fairs the modern and up-to-date exhibitive facilities which they need."

Capital for Australia

In the nine years up to 1956 Britain invested over £A400 million in Australian industry. This money has been widely spread with the biggest share going to heavy industrial equipment, electrical engineering, motor vehicles, chemicals paper making and textiles. Some 400 British companies now have a stake in Australian industry either as manufacturers themselves or as shareholders in local firms. British capital accounts for nearly two-thirds of all private investment. If mining is taken into account as well as manufacturing industry the figures are even more spectacular.

American investment in Australia, although on a smaller scale, is highly important and is likely to become more so. The United States invests £A290 million in Australia of which two-thirds is in manufacturing industry. Some 185 Australian firms are subsidiaries of, or associated with, United States companies. A further 400 firms have a licencing or royalty link up with American companies. The principal interests involved are in engineering, chemicals, food-processing and oil-refining. The biggest profit earner is General Motors-Holden's Limited, which dominates the Australian motor-car industry. With the big and rapidly growing markets of South-East Asia within striking distance there is plenty of scope for development in Australian industry; Britain is playing a major part in its expansion.

Letters to the Editor

TECHNICAL WRITING

SIR, Mr. Hoare, from his letter published in your issue of December 13, page 740, appears to have read my own letter (ENGINEERING, November 29, page 676) with insufficient care, since, if he will be good enough to re-read it, he will not find substantiation for either the second paragraph or the last paragraph of his letter in what I have said in mine. In his second paragraph, he states that in his view it is not necessary for a writer to be actively engaged in the research, development, production or use of the article under review. This is not suggested as being necessary in any part of my letter. What I did say was, that the writer should have adequate technical training to enable him to have a proper appreciation of the fundamentals of what is being described.

In the last paragraph of his letter, Mr. Hoare seems to imply that I have "expected" labourers to be able to undertake technical writing. What I said was, that, during my earlier experience, I had had in my charge labourers who have had barely the ability to write. On this point, in fairness to those less fortunate in the matter of education, I have sometimes been very surprised at the excellence of the writing of semi-technical reports by completely untrained people, such as railway lengthmen and the like, who have on occasion to make written reports of incidents occurring on the lengths for which they are responsible. Both my father, as a professional archaeologist, and I, as a civil engineer, have found that some of the keenest and most accurate observers and recorders of natural phenomena are numbered among those who have had the most limited amount of what we care to call formal education. To me, this implies that education, in its true sense, is something which is as likely to be acquired by an enthusiast, no matter how humble, studying on his own, as by the more fortunate attending formally directed courses of study.

Yours faithfully,
A. H. TOMS.

Waterloo Station,
London, S.E.1.
December 18, 1957.

INFORMATION SCIENTISTS

SIR, As you are aware, the work of scientific and technical information departments in all branches of industry, and in research associations, Government departments, and official bodies generally, has been steadily growing in importance. Nevertheless, as pointed out in my letter in ENGINEERING of June 7, 1957 (page 709), there is as yet no organisation concerned with professional qualifications for those engaged in such work, and interested in establishing high standards in the new synthesis of techniques involved.

After discussions over several years, many of us have come to the conclusion that a new professional organisation is necessary. To avoid difficulties caused by varying descriptions hitherto used for information workers, the name "information scientist" was suggested some time ago, and this name is now put forward in our proposals.

A meeting will accordingly be held, under the chairmanship of Dr. Malcolm G. Dyson, on January 23, at 5.30 p.m., at the Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2, to discuss terms of inauguration for an *Institute of Information Scientists*. The aims of the proposed Institute would include the promotion of high standards in scientific and technical information work, the promotion of educational courses, and the establishment of qualifications for persons engaged in such information work. Membership of the Institute would be open, in the first place, to graduate (or equivalently subject-qualified)

Continuing Letters to the Editor

members of scientific, technical or economic information departments. All who are interested in the proposal, and who come within the broad category indicated above, are invited to apply immediately for admission tickets, by writing to me at the address given below. Applicants should indicate briefly their qualifications and enclose a stamped addressed envelope for reply.

Yours faithfully,
J. FARRADANE.

Torran,
Crofton-road,
Orpington,
Kent.
December 18, 1957.

AIMS OF A SOVIET JOURNAL

SIR, We of the editorial staff of *Yuni Tekhnik* (a Soviet junior technical magazine) have read Plain Words in your issue of October 25 (page 514) and the letter which followed it in your issue of November 1 (page 550), and thank you for your kind words concerning our journal. It was pleasing to learn that your great journal had referred so generously to our young one, which first appeared only in September, 1956.

We entirely agree with the thoughts expressed in Plain Words—certainly a scientific-popular journal for young people is capable of playing a major part in the business of training future craftsmen and engineers and may help the young to choose a specialist technical field for themselves. Publication of such journals might be of national significance.

The magazine *Yuni Tekhnik* is intended for schoolchildren of the middle and senior classes. It is already apparent from the title that it serves technically minded young people, who are carried away by engineering and the exact sciences, and enjoy working with instruments, making models, machines, apparatus and tools.

However, the cherished ambition of our journal is that those schoolboys who wait impatiently for the end of the physics lesson, who walk past machines with indifference, and never feel the wish to do something with their hands, should become our readers. To reveal to these youngsters the greatness and beauty of engineering and science; to draw the attention of young people to the work in factories, mines, shipyards and tractor stations; to help them select their professions in exact science or engineering work—that is our aim.

Our journal seeks to keep its readers in touch with the latest events in science and technology at home and abroad; to show them the perspective of development; and also to give an account in our pages concerning the fundamentals of science and engineering; and to demonstrate how the laws and formulae which readers have learnt in school are embodied in technology. Problems requiring the use of drawing instruments are also included.

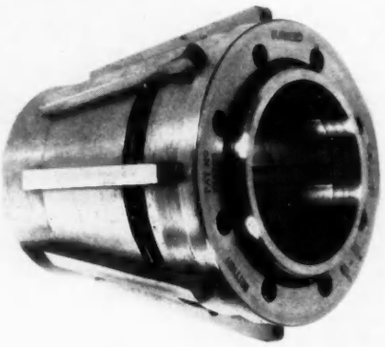
Our object is that our readers should learn to think technically and to develop an engineering imagination, resourcefulness, and the ability to apply their knowledge to practical problems. We have no sympathy for those who wear kid gloves, and the fewer that remain the more successful we regard our efforts; therefore, we ridicule such people in every way and try to teach our readers to think and work harder, to strive for the good of the community, to construct miniature hydroelectric stations, steam engines, to fit up their schools with radio and so on.

In answer to the question put by the editor of the *Meccano Magazine*, the circulation of *Yuni Tekhnik* is 200,000 copies a month. Thank you, again, for your comment on our journal.

Yours faithfully,
V. BOLKHOVITINOV,
Editor-in-Chief.

Yuni Tekhnik (Young Technician),
Moscow.
December 4, 1957.

Plant and Equipment



The Burnerd collet will accommodate any diameter of stock or component in a range of $\frac{1}{8}$ in.

COLLETS WITH GREATER TOLERANCE

A new collet, which combines the dimensional flexibility of a jaw chuck with the accuracy and high gripping power of a normal spring collet, is announced by F. Burnerd and Company, Limited, 5 Balfour-place, Park-lane, London, W.1. It has a dimensional flexibility of $\frac{1}{8}$ in., and the range of eleven collets now in production covers all sizes from $\frac{1}{8}$ in. to $1\frac{1}{2}$ in. Other ranges are in preparation. Six or eight narrow wedge-shaped blades, depending on the size of the collet, are spaced radially in the tapered steel body. When brought into operation, the blades exert a gripping action parallel with the workpiece within their centre over their whole length. A machining accuracy of within 0·0005 in. at 4 in. from the nose of the collet is claimed.

A special chuck is available for use with the collet, and it can be supplied with various types of mounting, direct on spindle noses (including American machine spindles) or by means of a flange. In operation, the chuck key turns a simple bevel gear and rotates an internally-threaded sleeve, which engages with a closer, or front cap. This draws the collet into the internal cone of the chuck. The workpiece is then inserted and the sleeve is further rotated until it is tight. An adjustable and removable end-stop permits accurate positioning of short components.

FLUORESCENT LAMP FOR HUMID ATMOSPHERES

For special projects, the A.E.I. Lamp and Lighting Company Limited, Crown House, Aldwych, London, W.C.2, have recently made fluorescent lamp fittings suitable for use in humid atmospheres where condensation may occur.

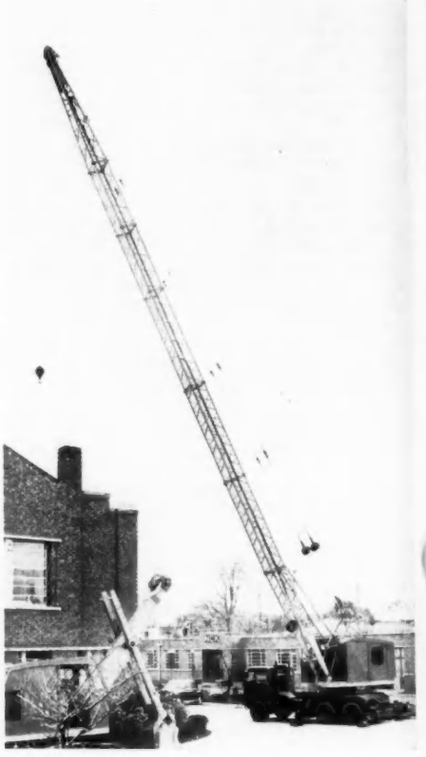
The new design has been applied to single-lamp 5 ft. fittings. In due course such fittings will be incorporated in the company's standard range. Two versions will be available: the Standard Watershed fitting and the Anti-Corrosion Watershed fitting. Both consist of a "Perspex" or PVC combined watershed and reflector, providing a cut-off and protection for the lampholders and the metal box housing the auxiliary gear. The power pack used with the standard watershed fitting is of heavy gauge sheet steel, bonderised and stove-enamelled white. Switchless starter gear is used. The lampholders have slip-over end shields.

The anti-corrosion fitting is basically the same as the standard one but the power pack and the lampholders are protected against corrosive agents. The power pack is of heavy gauge sheet steel completely sealed and coated with a paint containing "Epikote" phenolic resin.

BULKHEAD LIGHTS

The Duolacent range of bulkhead lighting fittings has been introduced by Heyes and Company, Limited, Water-Heyes Electrical Works, Wigan. The front covers of this new range incorporate both convex and concave surfaces in the one moulding, but have internal prisms only. It is claimed that this arrangement gives a better light dispersion from a given wattage and is very much easier to clean. The unit at present is made in one size to accommodate up to 100 watt lamps, but it can be supplied with bases in cast iron, cast aluminium, cast brass or porcelain. The use of porcelain is particularly suitable for installations where hygiene is important or where the light is subject to corrosion.

LONG BOOM CRANE



The 100 ft. boom is the largest of the NCK truck-mounted range of cranes.

A truck-mounted crane with a boom 100 ft. long, has been added to the range manufactured by Newton Chambers and Company, Limited, Thorncliff, Nr. Sheffield. The truck chassis used in the NCK 304 model shown in the illustration is based on Ministry of Supply specifications for military use. The carrier unit is powered by a 11·3 litre Diesel engine, developing 144 b.h.p. at 1,800 r.p.m. The main gearbox supplies five forward speeds and an auxiliary transfer box is fitted. The maximum road speed is 27·5 m.p.h. and the vehicle can be stopped and started on a gradient of 1 in 4. A special auxiliary air brake is provided to hold the machine on the stiffer gradients. The lifting capacity is 15 tons at 10 ft. radius, when equipped with a standard 35 ft. lattice type boom. Stability for heavy lifts is obtained by extending the I-section outriggers on the truck to 13 ft. jack centres. The NCK 304 can be converted readily from crane work to excavator purposes using shovel, drag line or drag shovel attachments.

The company also make a smaller truck-mounted machine, the NCK 205, which has a half cubic yard capacity.

MOBILE PLANT FOR CONDITIONING TRANSFORMER OIL

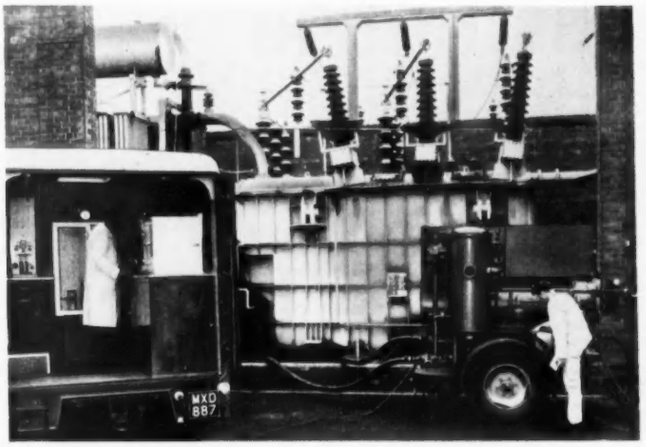
Degassing, Dehydration and Filtration on Erection Site

The first complete mobile transformer oil servicing unit to be operated in this country has been put into service by Manchester Oil Refinery Limited, Irving-road, Trafford Park, Manchester, 17. It comprises a mobile test laboratory and transformer-oil processing plant designed to carry out the degassing, dehydration and filtration of insulating oil at the site of erection of heavy electrical equipment. Flexible in operation, it is capable of ensuring that the properties of transformer oil remain at the highest possible level from filling to commissioning. Practical trials have shown that, on new equipment, breakdown voltages of 80 kV can be achieved after only comparatively short treatments.

An interesting application of this unit is the removal from oil of water which has accidentally entered the transformer. Such an operation is normally lengthy, tedious and costly, involving the use of electric power to heat the core, windings and oil so that absorbed water and gas are eventually driven off. Treatment of this nature can take several weeks whereas the M.O.R. unit completes it in a matter of days and can raise the breakdown voltage of the oil well in excess of the requirements of B.S. 148/1951.

The weight of modern high-voltage transformers—120/160 tons—has made it necessary for manufacturers to reduce the transit weight by delivering them to site either gas-filled or under vacuum. They are then filled with insulating oil from bulk road tank vehicles. This operation must be carried out with great care, especially in those areas where the atmosphere is contaminated with chemical impurities and is of high humidity. Even traces of moisture, either free or dissolved in the oil, and/or pockets of gas trapped in the transformer windings, can provide a conductive path and adversely affect operational efficiency. The new M.O.R. unit has been designed to obviate these difficulties.

The processing section of the unit comprises a coarse filter, oil heater, filter press and spraying tank, and pumps for circulation, vacuum drawing and delivery. Valves and interconnecting pipework enable different processing treatments to be quickly and easily selected. Maximum throughput rate is 1,000 gallons per hour.



The M.O.R. transformer oil servicing unit carrying out the conditioning of transformer oil on site. The mobile laboratory, left, is equipped to execute test procedures required by B.S. 148/1951.

The M.O.R. servicing unit utilises both static and dynamic vacuum dehydration concurrently. A spraying technique further increases the rate of drying. By means of fine spraying into a region of low pressure the oil is given a large surface area facilitating dehydration which can then take place at relatively low temperatures.

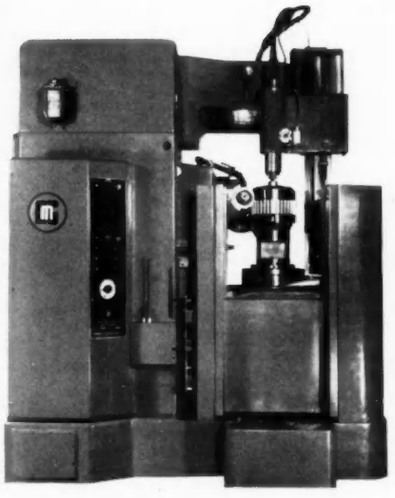
Large amounts of water present in liquid form, however, cannot be completely volatilised by simple spraying. To deal with this, a heater bank is provided to raise the temperature of the oil to any desired level.

Filter units designed to operate over a wide temperature range ensure that all traces of impurities—fibre, paper and metal which may contain occluded moisture—are effectively removed. In addition the plant is so arranged that dried and degassed oil cannot be contaminated by moisture already removed. This is impossible with conventional filtering equipment.

The vehicle used for towing the processing plant is fitted out as a mobile laboratory and has facilities for executing most tests required by B.S. 148/1951. In addition, water content by the Karl Fischer method, oil volume resistivity and dielectric strength tests up to 80 kV may be determined as necessary.

HOBBING BIGGER GEARS FASTER

The latest addition to the Churchill-Cleveland range of gear hobbers, the "S.1418," made by Churchill Gear Machines, Limited, Shibdon-road, Blaydon-on-Tyne, Co. Durham, has a greater working capacity than any of the company's previous models. It is designed to incorporate all the well-known Churchill-Cleveland features, and to be as simple as possible, both for operation and for maintenance. To meet possible requirements in the future for hobbing at higher speeds and feeds than are likely at present, the rigidity of the machine has been increased, and provision has been made for mounting a main drive motor of higher rated capacity than that fitted as standard. The working cycle is fully automatic with hydraulic work clamping and locking of the hob head slide during cutting, and the machine can be used in conjunction with automatic loading and unloading devices. The principal specification features are tabulated below



The new Churchill-Cleveland gear hobber retains the basic features of earlier models, but is of increased capacity, and is designed for higher speeds and feeds.

Maximum rated diametral pitch ..	4
Maximum face capacity:	
Spur gears and pinions ("square" cycle hobbing)	$9\frac{7}{8}$ in.
Helical gears (45 deg. helix, 9 D.P., $14\frac{1}{2}$ deg. P.A.) ..	9 in.
Maximum blank diameter (depends on hob head used)	13 in. to 16 in.
Minimum centres, work spindle to hob arbor (depends on hob head)	$4\frac{1}{2}$ in. to $5\frac{1}{4}$ in.
Max. and min. heights, work spindle to centre of hob arbor ..	18 in./8 in.
Maximum height, work spindle to tailstock centre	34 in.
Maximum diameter of hob ..	6 in.
Hob arbor diameter	$1\frac{1}{4}$ in. or $1\frac{1}{2}$ in.
Feed range:	
Vertical, per revolution of work	0·006 in. to 0·25 in.
Infeed of hob slide	0·040 in. to 59 in. per minute.
Rapid traverse rates:	
Work head	42 in. per minute.
Hob slide	59 in. per minute.

Main drive is by V-belts from a $7\frac{1}{2}$ h.p., 1,500 r.p.m. electric motor mounted in the main housing of the machine, and accessible through a hinged cover at the rear. A coolant pump, drawing its oil from a tank of 27 gallons capacity, is also driven by the main drive motor. Coolant flow is at a generous rate, to allow high-production hobbing. A new type coolant nozzle is fitted to give greater flexibility in the control of coolant flow in the cutting area.

Another compartment at the rear of the machine houses the hydraulic pump and controls. The hydraulic pump is driven by a $1\frac{1}{2}$ h.p., 960 r.p.m. motor, and provision is made in the design for additions to the hydraulic circuit for operating special fixtures and loading mechanisms if required. Steel piping and solderless joints are used throughout the hydraulic circuit, and a pressure switch is incorporated to prevent operation of the machine if the hydraulic pressure should fall below a pre-determined figure.

Similarly housed at the rear of the machine is the rapid-traverse motor, which is of $2\frac{1}{2}$ h.p. at 2,850 r.p.m. This gives rapid return of the work head to its starting position after the cutting cycle is complete. An electro-magnetic brake, mounted on an extension of the motor shaft, is a new feature on this machine; it replaces the shoe-type brake used on earlier models.

A new type of hob head, of specially robust construction, is fitted. It is manufactured in two sizes, 3 to 1 or 4 to 1 ratio, and can be equipped with continuous or intermittent hob-shifting mechanism, by means of which hob life is increased considerably. Intermittent hob shift, which can be in increments from zero to 0·25 in. per cycle, is pre-set on a scale graduated in 0·001 in. increments. The maximum length of shift is 3 in., but it can be set to any distance between zero and the maximum. A warning light is illuminated at the end of the hob-shift stroke, and the machine is automatically prevented from commencing a new cutting cycle.

Special Article

THE MOTION OF A YACHT THROUGH AIR AND WATER

A Discussion of some of the Hydrodynamic and Aerodynamic Considerations Influencing Modern Yacht Design

By W. A. Crago, B.SC., A.F.R.AE.S., A.M.I.N.A.*

YACHTING for pleasure is a very old pastime indeed. For example, there is evidence to show that the Ancient Greeks and the Romans enjoyed the sport and there is no reason to believe that it was confined to them. In England the first recorded yacht race took place in the Thames and Charles II who was aboard one of the yachts was reputed to have taken the helm. Subsequently the popularity of yachting in this country grew considerably, and its final denouement is evidenced by the fact that in 1833 King William IV placed himself at the head of the premier yacht club and graciously commanded that in future it should be known as the Royal Yacht Squadron. The King also presented a cup to be raced for annually and it is an interesting commentary on the state of yachting in those days to note that in the first five years the cup was won by yachts all having displacements of over 50 tons, and one was nearly 200 tons.

In spite of the popularity of yachting, progress in design remained sporadic until about 1920, and it is instructive by way of introduction to review briefly the changes that have taken place in the last 40 years. At the beginning of this period racing yachts were generally from 40 to 85 ft. long on the water line, and anything having a length less than 30 ft. was regarded as a toy for young people. Professional crews were common and yachting was mainly a rich man's pastime. By the 1930's the Bermuda rig had become popular and increased attention to the sails also resulted in such things as the parachute spinnaker and the quadrilateral jib. Ocean racing was becoming more popular and the smaller classes of yachts were gaining ground, but probably in the public eye yachting was still epitomised by the great J class boats and names like Enterprise, Shamrock, Endeavour and King George V's Britannia are still remembered to-day. Very little occurred of course during the next decade, but since the war yachting has reflected the changed economic situation, and the average size of yacht has rapidly decreased while the price per ton has risen, furthermore, keel boat classes have largely given way to smaller centre board classes. In spite of these considerations it has been estimated that five times as many people sail to-day compared with 1939.

With technical progress evident on every hand it is reasonable to look for a comparable advance in yacht design. The investigator, however, soon becomes conscious that yacht design is a field which has not been regarded as wholly scientific but which has had strong affinities with the arts. Nevertheless, even in the last few decades changes have taken place in architecture and painting, and new art forms have made their appearance, and therefore it is still rather surprising to the casual investigator to find that the shape and performance of the average yacht has changed so little in the last twenty or thirty years. He may be tempted to conclude that the impact of modern science on yacht design has been negligible or confined to fittings, radio, etc.

One reason for the apparent lack of obvious progress in design is the stultifying effect of the measurement rules. The rules were intended in effect to eliminate the performance of the yacht itself from any yacht race so that the isolated skills of the helmsmen might be pitted against each other. From a purely sporting point of view this is a laudable object but it has led in practice to the talents of the designers being constrained and confined to produce yachts which fit in with the rules while maintaining adequate if not outstanding performance. Furthermore, impractical measurement rules have led to " rule cheating " and the evolution of yacht designs which would never have been built if efficiency and comfort had been the sole design criteria.

The bad effect of the measurement rules cannot be blamed on the designers, owners, or the formulators of the rules who did their best whilst lacking adequate data on the parameters which define a yacht's performance. It is due, rather to the sporting nature of yachting as a whole. However, wherever there is competition, scientific techniques are eventually utilised and it is the purpose of the rest of this article to review some of the effects—contemporary and future—of modern science applied to yacht design.

MECHANICS OF SAILING

In attempting to review these effects it is necessary to have an understanding of how a yacht can utilise the energy of the wind and turn it into a propulsive force. When every relevant factor is taken into account the exposition of the mechanics of sailing can become exceedingly complicated, but the basic principles can be grasped easily by considering the aerodynamic and hydrodynamic forces separately—and then adding their effects together. We will consider a yacht going to windward, and whilst what follows is sufficiently precise for our present purpose, it is by no means a rigorous explanation.

Fig. 1 shows the section of a sail placed in a wind. The sail may be considered as an aerofoil or wing and in the conventional manner it may be regarded as producing a lift L_s and a drag D_s which have a resultant F_s. This resultant force F_s can be resolved into two other forces at right angles as shown in Fig. 2. These two forces are the sail thrust T and the sail side force S.

Now consider a hull moving through the water with an angle of yaw or leeway as shown in Fig. 3. The hull may also be regarded as an aerofoil and it produces a lift L_H and a resistance R_H. If Fig. 2 is compared with Fig. 3 it is immediately apparent that the sail thrust can be used to overcome the hull resistance while the unwanted but unavoidable sail side force can be balanced out by the hull side force. Consideration of Fig. 4, which is a front elevation of a yacht, shows that the sail side force and the hull side force combine in an attempt to heel the yacht over and this effect must be countered by the natural stability of the hull.

It is now pertinent to inquire what determines the magnitude of the forces that have been mentioned. As might be expected, the sail forces are determined mainly by the sail setting, the sail area, the relative wind speed and the angle of heel whilst the hull forces are determined mainly by the water speed, the hull shape and the angle of leeway. Furthermore, the angle of heel is determined by the sail side force and its position of application, the yacht's weight and its metacentric height. This latter term is a function of the separation between the centre of gravity and the centre of buoyancy and may be taken as a measure of the yacht's stability in heel.

The whole art or science of yacht design rests in obtaining a satisfactory relationship between the various forces that have been specified. This statement may be illustrated by considering one of the more important characteristics of a yacht, namely, the " balance."

Implicit in the explanation of sailing given above is the function of the helmsman whose job amongst other things is to adjust the sails and helm so that a stable balance of sail, hull and rudder forces is achieved and which gives the best speed made good to windward. If the yacht is badly balanced, the sail side force and the hull side force may be displaced from each other by a considerable amount in a longitudinal direction,

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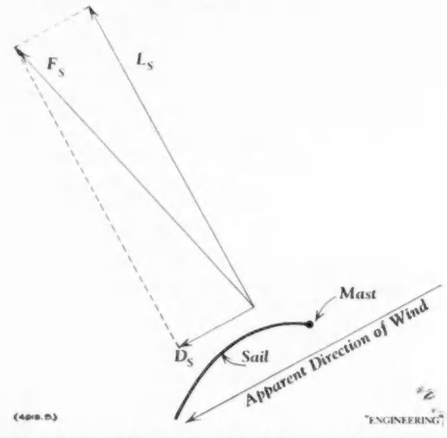

Fig. 2 A sail section placed in a wind produces lift L_s and drag D_s, having a resultant F_s.

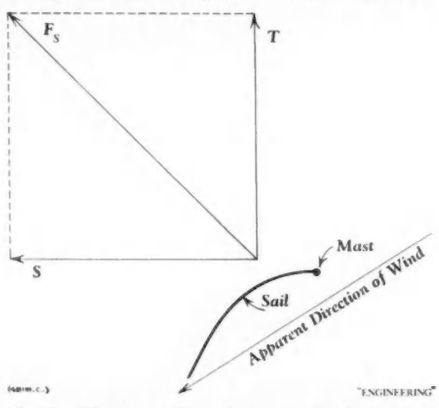

Fig. 3 The force F can be conveniently resolved into a sail thrust T and a sail side force S.

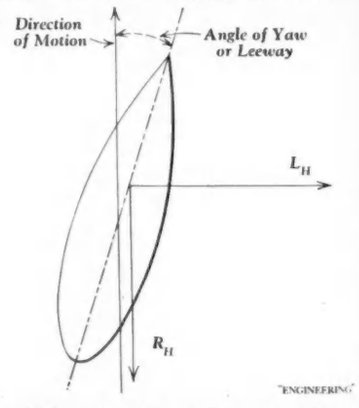

Fig. 4 A hull moving through the water with an angle of yaw can also be regarded as an aerofoil.

as shown in Fig. 5. They then produce a couple which is very difficult to oppose with the rudder force. When the hull force is forward of the sail force, the yacht is said to carry "weather helm" whilst if the opposite holds good then the term "lee helm" is employed. A slight weather helm is much to be preferred since a sudden squall will result in an increase of the sail side force which will in turn cause a moment on the hull which will then turn the hull and sail into wind. This will reduce the sail angle of incidence and thereby relieve the severity of the sail load and hence the heeling moment. Lee helm does not provide this inherent safety feature and may lead to the yacht being blown over.

From the basic theory set out above it is possible to consider what changes in design can be made to obtain a better performance. These changes fall into two categories. First, those associated with the hull, and second those associated with the sails.

Fig. 1 Results of model tests have been supported by tests with an instrumented 5·5 metre yacht—"Yeoman." The data obtained brought to light certain features of sailing that were not perhaps fully realised previously.

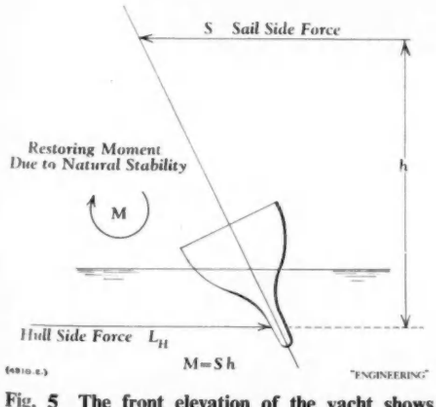

Fig. 5 The front elevation of the yacht shows the forces tending to heel the yacht over.

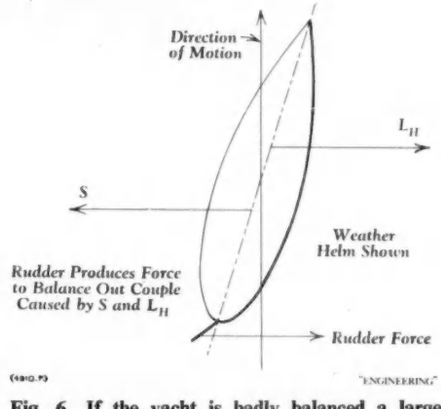

Fig. 6 If the yacht is badly balanced a large couple is set up by the hull and sail side forces.

HULLS

There are two main possibilities, namely:

(1) Increase the hull side force/resistance ratio, L_H/R_H, either by increasing L_H or by decreasing R_H throughout the whole or part of the range of leeway angles.

In general, for any given hull geometry an increase in the hull side force L_H requires an increased leeway angle, which is inevitably associated with an increase of the resistance RH. However, certain design changes can be made which allow an increased hull side force to be guaranteed without a resistance penalty.

(2) Increase the hull stability. As the yacht heels, the sail heels also and its efficiency is much reduced; furthermore, the amount of sail force that can be handled in practice is generally limited by the heel caused. Thus an increase in hull stability which does not carry an unduly large resistance penalty will help to reduce the heel for any given sail force and cannot help but be beneficial.

Attempts have been made to meet requirement 1 above by using the results of aerodynamic theory, which shows that the induced drag of a "wing" can be made smaller by increasing the aspect ratio. Thus, yachts have been built with very deep keels or centre boards which have small chords. There is little doubt that they are more efficient than the conventional keel and better values of L_H/R_H result, but when ballast has to be carried on the bottom of the keel it has been regarded in the past as much more practical to adopt the conventional form. Of course, the deep keel also implies a greater separation of the forces making up the couple to be resisted by the hull stability. Clearly, there is an optimum keel depth beyond which it does not pay to go.

Any reduction of the hull resistance R_H while maintaining the hull side force L_H is helpful and in this connection it is often assumed that it is desirable to design a yacht to plane at low speeds. In general, this is quite untrue. Fig. 6 shows the resistance curves for a typical small yacht compared with an equivalent planing hull. As is readily apparent the planing hull is only of use above a speed length ratio of about 1·8 in this particular case.

High speed planing (i.e., at $V/\sqrt{L}$ values above about 2·0) is attractive not only because it may lead to a greater race winning potential; it is also great fun and adds a zest to sailing which must be felt to be appreciated. In this connection the advent of constructional materials and methods giving high strength/weight characteristics has been associated with a decreased overall weight of yacht for a given length, and it is generally assumed that if the ratio Δ/L^3 (where Δ is the weight in pounds and L the waterline length in feet) is less than 0·2 and the

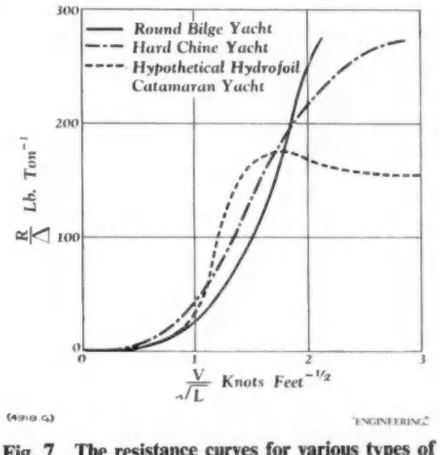

Fig. 7 The resistance curves for various types of hull configuration are compared.

Continuing Special Article

ratio of sail area to static wetted area exceeds 2, then it will prove relatively easy to make the yacht plane. Such requirements cannot be considered as scientifically rigorous but they provide a reasonable and practical guide.

It is generally accepted among yachtsmen that a reduction of the surface roughness of the hull by scrubbing and polishing will produce a reduced resistance and hence a higher speed.

Fig. 8 In the last few years the true potential of the catamaran has begun to be exploited. Craft have been designed which depend entirely on the hydrodynamic forces acting on their hulls for their heeling stability. Catamaran craft normally have both hulls in the water.

However, the situation is not as simple as it first appears.

At the bow, two forms of fluid flow are possible in the boundary layer adjacent to the hull side. The first is termed " laminar " and will persist until for some reason or other it breaks down into " turbulent " flow. The reason for the breakdown is generally roughness on the surface or motion in the water (e.g., due to waves). Laminar flow is associated with a lower viscous traction on the hull surface than that caused by turbulent flow and hence laminar flow is to be preferred and encouraged where possible. However, separation of the boundary layer from the hull side (which results in considerable increases in resistance) more readily occurs with laminar flow, and while the speed range where this is possible generally makes its consideration rather academic it may well be of importance with small and unorthodox yachts. In the writer's opinion it is generally not worth while trying to delay the onset of turbulent flow by making the hull smooth. On the other hand, every single growth on the hull bottom must contribute something to the resistance.

The second of the possibilities derived from consideration of our elementary theory is the increase of the hull rolling stability. The orthodox yacht is already extremely stable due to its ballast keel. This ballast, however, increases the hull displacement which in turn increases the resistance, and it is clearly inefficient to have to carry anything from 30 per cent. to 50 per cent. of the total displacement of the yacht as ballast. Thus, in the quest for better performance, designers have been led to look for increased stability without the increased displacement and its associated resistance penalty. Put in another way, the designers wish to increase the power to carry sail and a very convenient and promising solution to this problem is afforded by the so-called " catamaran" configuration in which two hulls are held separated from each other by cross members. The lateral distribution of buoyancy results in a large effective metacentric height and a high degree of heeling stability.

The word " catamaran " owes its derivation to two Indian words which mean a " tied tree " and the linking of two hulls with bamboos is an old idea in the Pacific as a visit to the British Museum will show. There is some argument as to whether the word can rightly be applied to the modern twin hulled yacht but it has entered into popular usage and will therefore be used here.

The first English " cat " was built in Charles II's time and is reputed to have broken up in the Bay of Biscay. By the end of the Nineteenth Century about a dozen were in use in American waters and some of them employed cross members which allowed the hulls to pitch separately. These must have been a fearsome sight in a rough sea.

More recently a number of American catamarans were built but the hulls were relatively heavy and employed water ballast. Thus they were a compromise, in that their heeling stability resulted partly from ballast and partly from the lateral buoyancy distribution. Although they could be fast under good conditions they manoeuvred poorly.

In the last few years the true potential of the catamaran has begun to be exploited and light craft have been designed which depend entirely for their heeling stability on the hydrodynamic forces acting on their hulls. Their success is a result not only of a true appreciation of the hydrodynamic problems involved but also of modern constructional methods which were for the most part originally developed for use with wooden aircraft.

The sail carrying ability of the catamaran type yacht and its independence of ballast can be illustrated by comparing the ratio $S^{5/2}/\Delta$ for a number of yachts. S is the sail area in square feet and Δ is the displacement in pounds.

Cruising yacht	1·0 to 1·4
J class yacht	2·0 to 3·0
12 metre class	1·5
6 metre class	1·0 to 2·0
Canoe	2·8
Catamaran	4 to 10

Being able to carry so much sail for a given displacement it is to be expected that the catamaran should be a fast craft. Most orthodox deep keel yachts do not exceed a speed length ratio of about 1·4 but values as high as 5·0 have been claimed for catamarans. That they are not restricted to calm water is evidenced by one 40 ft. catamaran that sailed from Honolulu to Santa Monica in California—a distance of 2,700 miles at an *average* speed of about 7½ knots.

At the high speeds of which a catamaran is capable the hull design ought to be considered from a very different viewpoint from that of an orthodox yacht. Most catamaran hulls are long and thin, and length-to-beam ratios as high as 18 have been employed. It may well be that still faster catamarans could be built having beamier hulls with chines and steps. Of course such a design would not be so good in light winds because of the increased wetted area and the seakeeping ability might leave much to be desired unless considerable ingenuity were employed in the design of the forward sections.

The catamaran configuration has other practical advantages, thus the space between the two hulls can be utilised to provide generous deck area for a bridge and all the other activities inseparable from the sport of yachting—such as fishing, sunbathing and the like. Furthermore, the transfer of the crew from one hull to the other is facilitated and their weight moment still further enhances the stability.

Another method of improving hull performance is the application of the hydrofoil. The hydrofoil, at first sight, seems more likely to meet requirement 1 rather than requirement 2, but the writer believes that its best application can be made in conjunction with the catamaran hull configuration.

The simplest definition of a hydrofoil is that it is an underwater wing producing lift in just the same way as an aircraft wing. The lift drag ratio of a hydrofoil can rise as high as 20 and such values have actually been measured on practical hydrofoils in the Saunders-Roe Test Tanks by the writer. Making allowance for rudders, struts and inevitable compromise it should still be possible to obtain a ratio as high as 15 when applied to a yacht. Thus, as soon as the water speed of the hydrofoil yacht becomes high enough, the hydrofoils would lift the hulls clear of the water surface and a very low resistance per pound of displacement would become possible. The resistance curve for a hypothetical hydrofoil yacht is shown in Fig. 6. By mounting the hydrofoils on the hulls of a catamaran the necessary heeling stability could be maintained in spite of the raised sail side force (due to the elevation of the hull and sails by the hydrofoils

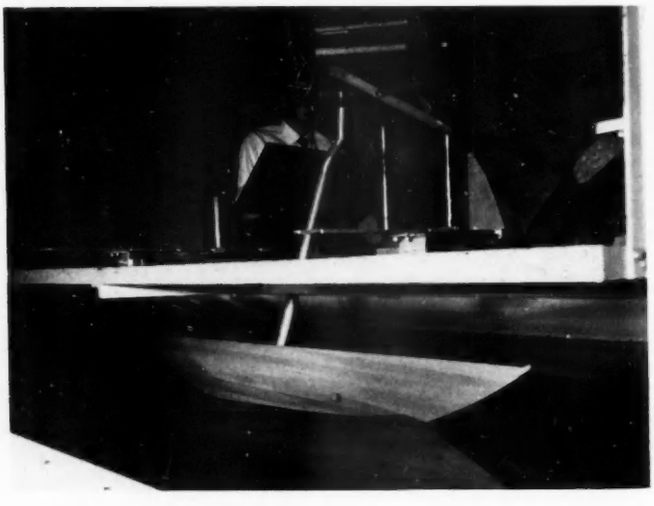

Fig. 9 Designs for " Sceptre " were evaluated by tests on tank models. The illustration shows measurements being taken during a low speed run.

lifting out of the water). The " hull " side force could be produced by the vertical struts of the foils.

Unfortunately this attractive scheme has certain inherent difficulties. The weight penalty of the foils and their supporting structure, while relatively low for a small yacht becomes a fair percentage of the total weight for a larger craft. Thus their application may not only restrict pay load but, although a good R/Δ may be obtained as shown in Fig. 6, the value of R may be high because the displacement has been made large as a result of the weight of the foils.

Obtaining satisfactory rise and longitudinal stability characteristics in calm water and in waves is a considerable technical problem which almost certainly calls for development tank tests. Nevertheless the writer believes that small hydrofoil catamarans are a definite possibility even now.

SAILS

That no major developments have taken place over the last 50 years in sail propulsion may be easily demonstrated by comparing a contemporary yacht photograph with one taken at the beginning of the century. The introduction of fairly high aspect ratio sails and the Bermudan rig may of course be regarded as advances but their introduction cannot be called a " major " development. Of course handling is better, and modern winches, rigging and masts are no doubt better than they were. These may be classed as necessary evils however, and the efficiency of the sail itself remains much as it ever was. The historian might have expected that the vast amount of aerodynamic data, both theoretical and practical, gathered over the last three or four decades would have resulted in increased efficiency of sails. However, the necessity of being able to reef rapidly, together with owners' natural conservatism has militated against rapid progress. Some practical experiments have been carried out, however, on full-scale yachts with advanced sail forms, but in order to understand their impact it is necessary to consider a little more closely just how the sail works. We have already compared the sail with an aerofoil and like the aerofoil the sail is acted upon by aerodynamic pressures on its surface caused by the passage of the wind. The integration of the pressures in any required direction together with the skin friction component gives the resultant force developed by the sail. Clearly, it is desirable to increase the ratio of sail thrust to sail side force, T/S, either by increasing the thrust or by decreasing the side force. Although not strictly logical this requirement in practice leads to the desirability of using a sail having a high lift/drag ratio (L_s/D_s) when the wind comes from any angle within the section measured up to 90 deg. from the bow. If this is accepted then it is clear from Fig. 1 that any reduction in the drag force D_s obtained by reducing the diameter of the mast or streamlining it, or by cutting down the size of the rigging wire will be helpful. Furthermore, an orthodox mast can so affect the flow over the sail surface that 20 per cent. of the lift may be lost. The usual induced drag penalty associated with aerodynamic flow over any three-dimensional wing can be aggravated by poor choice of sail planform and further vortex losses can take place under the jib. Most sails are porous to a certain extent and this further reduces their efficiency.

The effect of a slat on a wing is to delay the stall, and to improve the characteristics beyond the stall. The foresail can be made to act as a slat in a number of cases. However, it requires little intuitive reasoning to deduce that the gap between foresail and mainsail will hardly ever be optimum and will generally be far from it, although the effect will still be beneficial to a certain extent. Orthodox flexible sails also suffer from twist (i.e., their angle of incidence is not constant along their length), and they cannot be run at small angles of incidence, otherwise they will not maintain the desired section and will flap.

In spite of the catalogue of faults listed above it is not easy to improve the orthodox sail configuration. Woven fibre material and more recently plastic sheet have helped in detail and some excellent performances have been achieved, but the impact of applied science is probably most obvious in the development of the wing sail.

The wing sail may be partly or wholly non-flexible and consists as its name implies of a wing erected vertically and free to pivot about a vertical axis. It will generate more lift per square foot of area than an orthodox sail, particularly if its section shape can be changed to suit the wind direction. Of course the thought of using such a structure on a large yacht is a little frightening but there is no doubt that they have immediate application for small craft sailing in relatively sheltered waters.

More advanced wing sail applications have been suggested in which the sail angle would be adjusted so that the resultant aerodynamic force generated by them would be near the hull centre of gravity, thus reducing the heeling moment. Such proposals suffer from difficulties of a practical nature but they will no doubt be developed further in due course.

MATERIALS

Recent years have seen the development of several new constructional techniques and new materials have been employed. Plywood has been extensively used while hulls employing moulded fibreglass and resin have steadily increased their popularity. Light alloy has lent itself to simple construction especially where conic sections are employed and at least one British firm has produced a large number of hulls using moulded wood laminations.

Of the above, probably moulded fibreglass and resin has the greatest development potential where small yachts are considered, and the replacement of hand laying up by mechanised methods can be expected to reduce costs and total moulding time. The following table shows a comparison of " quantity production " manufacturing costs for similar small dinghys:

Comparison of Manufacturing Costs of Small Dinghys

Type of Construction	Cost of Materials	Cost of Labour	Weight (lb.)	Comment
Plywood	£10	£12	80	—
Cold moulded timber	£14	£22	78	—
Cold fibreglass and resin	£18	£16	97	—
Hot moulded timber	£14	£3	78	—
Hot fibreglass and resin	£18	£0·5	97	The reduction in labour costs due to production technique is very marked.

MODEL TESTING

Both the aircraft and ship world have gained immeasurably from the technique of testing models in order to predict and improve full-scale behaviour. Thus it is surprising to find how little model test work has been carried out on yachts. Notable pioneer work has been carried out by the Stevens Institute in America and more recently the National Physical Laboratory have carried out tests on model yacht hulls. Latterly, Saunders-Roe Limited, in their own tank, have carried out extensive investigations and among others, nine 12-metre yacht models designed by various expert Naval architects were tested. In this way the choice was made for the design for the Americas' Cup challenger Sceptre.

The modern method of yacht model test is of course a thoroughly representative one in which the model hull makes leeway and heels under the influence of wind and water forces. Sails are not represented but their effect is simulated by the mechanism of the special dynamometer employed, and any required sail characteristics can be used to predict the full-scale sailing behaviour.

The validity of such model work has been established not only from the results of competitive sailing but also by full-scale tests on an instrumented 5·5 metre yacht. The instrumentation was designed and built by the writer's firm and the test work was carried out by an independent yacht association in conjunction with the National Physical Laboratory. The data when analysed presented certain problems of interpretation and brought to light certain features of sailing that were not perhaps fully realised previously. Excellent correlation was found between the model and full-scale regimes and the usefulness of yacht model tests established beyond doubt.

CONCLUSIONS

In the writer's view the prevailing economic situation will probably preclude the kind of rapid development that has taken place in the aircraft and other similar industries. However, the potential for rapid progress exists in the catamaran and hydrofoil applications among others, while new materials and construction techniques can be expected to become more significant as their effect on cost becomes more pronounced.

The place of systematic model yacht tank testing seems assured since the hit and miss procedure sometimes used to good effect in the past will have less probability of success as the complexity of the yacht configuration increases. Application of such scientific methods can frequently reduce painful years of full-scale experiments to a few hours in the tank.

Undoubtedly there will always be a large number of yachtsmen who want to go sailing without being greatly concerned about the efficiency—or otherwise—of their craft, but even these will undoubtedly benefit in time, under the influence of techniques originally applied to unorthodox high speed yachts.

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Obituary

MR. F. G. WOOLLARD, M.B.E.

We note with regret the death of Mr. Frank George Woollard, which occurred on December 22 in hospital in Birmingham. Mr. Woollard, who took a leading part in developing mass and flow production and what has come to be known as automation in engineering shops, was born in Kensington, London, in 1883 and educated at the City of London School. He served his apprenticeship in engineering under the late Mr. Dugald Drummond, M.I.C.E., of the London and South Western Railway Company, at Eastleigh, and subsequently joined the firm of Weigel Motors (1907) Limited. Mr. Woollard went to the Midlands in 1911 to take up the position of chief draughtsman to E. G. Wrigley and Company, Limited, Soho, Birmingham. Subsequently he became chief engineer and assistant managing director. It was during this period of his career that Mr. Woollard took a lead in developing flow production for motor-car components. For his work as consultant on gears for Army tanks during the war of 1914-18, he was made an M.B.E. In 1923 he joined the Engine Branch of Morris Motors Limited and was later made general manager and a director of Morris Motors.

From 1932 until 1936 Mr. Woollard was assistant managing director of Rudge-Whitworth Limited, Coventry, and from 1936 served on the boards of the Midland Motor Cylinder Company, Limited, and Birmingham Aluminium Casting (1903) Company, Limited, Smethwick, until his retirement in August, 1953 when he took up consulting work. Mr. Woollard was President of the Institution of Automobile Engineers at the time of its amalgamation with the Institution of Mechanical Engineers, in 1947, and became the first chairman of the Automobile Division of the latter body. Mr. Woollard was also a member of the Institution of Production Engineers. He had, moreover, served as chairman of the Executive Committee of the Aluminium Development Association and as chairman of the Council of the Zinc Alloy Die Casters' Association.

The Human Element

Omens and Auguries

Talk of recession and unemployment was becoming general at the year end. There was a feeling that the main factor in the changing climate was not our own Government's actions at all, but loss of confidence in American manufacturing circles. United States cuts in buying raw materials sparked off the most spectacular fall in commodity prices (raw materials and food) since the war. Some authorities were heard to say that President Eisenhower's Government could do very little about it—no-one was fool enough to buy on a falling market. It is of course a most serious situation for the rest of the western hemisphere and particularly for Britain, for it must lead to reduced imports by primary producing countries and therefore to sharp falls in our exports in the spring. In this context, the reported decision of the United States Government to initiate a vast programme of off-shore purchases for the N.A.T.O. forces in Britain, France, Germany and elsewhere may offset to some extent the effects of the contraction of home markets, but not when it coincides with major, and controversial, changes in strategy involving whole industries. With their Christmas turkeys barely digested, workers at Saunders-Roe's factories in the Isle of Wight and elsewhere heard that Government support for the SR 177 supersonic rocket-and-jet engined interceptor aircraft had been withdrawn.

Agreement on Diesel Manning

The successful outcome of negotiations between the two railway unions, the N.U.R. and the A.S.L.E.F., and the British Transport Commission on the manning of Diesel and electric locomotives towards the end of last year is due reward for patience and sensible compromise. Britain is one of the first countries to solve the human problems involved in the switch away from steam.

The agreement has been ratified and came into force on January 1, but certain technical changes will be needed to make it fully effective. Of these the main one is that trains should be completely fitted with vacuum brakes; this will take time. Other conditions are the exclusion of non-stop passenger journeys over 100 miles or 2 hours (200 miles and 6 hours for stopping journeys), and similar freight journeys; and the continuation of double manning for journeys between midnight and 6 a.m.

No significant change is expected within the first six months of the agreement's operation (only 4 per cent. of freight trains are fitted with vacuum brakes) and when it takes place the main weight of redundancy is expected to be borne by natural wastage and non-recruitment. Although the total number of drivers and firemen will be reduced to 60,000, by about 25 per cent., no hardship should be caused and some compensation will be paid out for loss of promotion prospects.

Knocking Heads Together

In the latest issue of *Optima*, Mr. Harold Holt, M.P., has contributed an article on the strike problem in Australia. Among other matters he raises the question of compulsory arbitration—which is law in Australia. This particular problem is of special interest in this country at the moment when the arbitration tribunals are likely to have a fairly busy and chill winter.

Mr. Holt points out that the conditions in Australia are unique. They are not directly comparable so far as the climate of industrial relations is concerned either with the United States or with the United Kingdom. Australia, he thinks, has neither the highly competitive industrial atmosphere of the United States nor the highly developed sense of community responsibility of this country. The Commonwealth arbitration tribunal provides this vital element of public responsibility. In a sense therefore arbitration in such an environment is not so much a chance to let tempers cool and basic commonsense assert itself as an opportunity to knock heads together. This winter may give the British public a chance to see how dearly it has bought this so-called industrial maturity.

The Four-Day Week

The likelihood of a four-day week is discussed in a recent issue of *Labour News from the United States*. It has its supporters and its opponents. The former include Vice-President Richard Nixon and Mr. Boyd Leedom, chairman of the National Labour Relations Board. Mr. Nixon predicted that the four-day week would be a reality in "the not-too-distant future" and Mr. Leedom "within two years." Among the opponents, a spokesman of the General Electric Company forecast a 20 per cent. drop in living standards if the four-day week is adopted in the near future. A vice-president of Ford Motor Company stated that the motor industry in the United States was a long way from the time when "technological progress and the resultant productivity will be so great that we have to worry about dividing up the available working hours." Yet another opponent, a professor from Columbia University, dreaded "too much leisure with too much money" as being the cause of the decadence and fall of nations.

The wish for increased leisure is said to be strong in the United States, strange as this may sound to those who believed Americans to be essentially work compulsive. The fact that the American people spend 10 per cent. of the national income—342 thousand million dols.—during leisure hours is a powerful appeal, provided of course that real incomes could be maintained or even increased.

Most unions will call for a shorter working week this year. Mr. Walter Reuther, president of the United Automobile Workers, will press for a four-day week in 1958. Others will call for less than 40 hours of work a week. All will fight unlimited overtime. Whether social or economic reasons are prompting union leaders is not clear, probably a mixture of both basic motives. In this country the four-day week looks far more probable as a measure to share out the work, that is short-time, than for any other reason.

Scholarships for the Independent

An imaginative and rather brave attempt is to be made to cut across the general structure of scholarship education with a new idea to which Dr. G. M. Trevelyan has lent his name. A new kind of selective method is to be employed in choosing a group of boys for entry into Oxford and Cambridge. Financial support is being provided by a group of companies and a steering committee has been established with representatives from industry, schools and the universities under the chairmanship of Sir Walter Benton Jones. The secretary is Mr. R. Peddie, 17 Westbourne-road, Sheffield, 10.

Sufficient financial support is forthcoming to ensure 12 to 14 scholarships of £450 per annum for the initial period of five years, irrespective of parents' means. The first selection is to be made in November, 1958. The sponsors believe that there are boys capable of holding their own academically who are penalised under the established education system. They hope to encourage any such boys to pursue a wide range of subjects in the sixth form. The selectors will look for evidence that a candidate can profit fully from an honours course and show that he has undertaken some exacting task or project. This may be an intellectual inquiry or one involving observation or travel. A written account of this must be submitted with a report on the boy from his headmaster. It is clearly intended to catch those who have some unusual and slightly unorthodox qualifications and those who develop late.

Not Born but Made

A special conference is being held by the British Institute of Management at Harrogate later this month on the subject of management development. The conference will concern itself with such subjects as where the managers of tomorrow are to be found and how they are to be trained. The speakers are drawn from industrial consultancy, from some of the largest industrial groups in the country and also from some smaller but go-ahead concerns.

The decision to hold such a conference is a sign of the amount of thought which is to-day going into the selection and training of potential managers. As usual, those who are taking part are those who are the foremost in realising the need for better managers. There is no danger of prejudging the conference in saying that this is a subject where it is only too easy to get a hearing among those who are already converted. How to deal with the larger field of British industry remains the biggest problem.

It is a very big problem. British industry abounds with inefficient management set-ups: concerns run by old men (or one old man) who will not delegate, family businesses trying to keep going for one more generation, top managers who have learned the hard way and therefore think that no one can teach them anything, directors who can only think in terms of shillings and pence and the large army of responsible executives who can or will only take the short view.

Two Thomsons

The week before Christmas saw the celebrations of two anniversaries—both of them of Thomsons of Scots extraction. The first of these was the centenary of the birth of J. J. Thomson, who is now in a very real sense part of the history of the Cavendish Laboratory. The other was the marking of fifty years since the death of William Thomson, better known as Lord Kelvin.

Comparisons in the world of science are often invidious and they would certainly be so here. At least a generation separated the two men (Kelvin being much the elder) but each in his way played a major part in the development of our knowledge of physical theory and its application. Separate in age though they were, their work touched at some points notably in their mutual interest in vortex rings as a possible explanation of atoms.

Different in age, the two men were also different in their attitude to academic study. J. J. Thomson made many and significant contributions to the application of physics but he started and ended on the theoretical side. Kelvin was both a theoretician and also a business man. His activities were probably known to a wider public and he was something of a character, familiar to people outside the academic world. As professor of natural philosophy at Glasgow University for fifty-three years he was at the heart of the expansion of the theory and practice of physics and engineering in the whole of the second half of the Nineteenth Century in the West of Scotland. He busied himself with many aspects of that expansion.

Continuing **The Human Element**

THE CASE OF THE BAD MIXER

By Z. M. T. Tarkowski, B.SC.

Our understanding of the psychology of people at work is growing every year. It can be expressed in language that is similar to the language of engineering. In this report Mr. Tarkowski examines the case of the bad mixer—a " type " often found in industry who could increase the value of his services if he could break the vicious circles which prejudice him in the eyes of his colleagues. In later articles Mr. Tarkowski will examine other cases of people in industry.

To be able to fit in smoothly is supposed to be an admirable quality. Acceptability, it seems, is one of the attributes most highly valued by employers. A bad mixer may miss promotion, he may risk dismissal, and may even become unemployable. He is avoided; no one wants to speak to him or to be seen with him. People refer to him by derogatory nicknames, disparaging remarks are casually dropped behind his back. Small things—gestures, tones of voice, facial expressions—all serve to build up a common feeling against him. He senses this atmosphere and that makes him worse.

And yet we know that the so-called bad mixer is often a man of outstanding ability and promise which could be fulfilled to general advantage, provided we could overcome the prejudice against him, and he could change in himself whatever it is that makes him objectionable.

The country badly needs more men of ability. There is a shortage of technical men and administrators. Potential leaders, as we know, are often rebellious and aggressive. But the prejudice remains; we value politeness and smoothness more than real ability. Is this attitude conducive to industrial and intellectual progress? It is obvious that a great number of able and gifted people are frustrated and thwarted, and yet these same people could be in the forefront helping to solve the problems of social and technological change.

Let us consider the case of Jim Meredith.

JIM MEREDITH

Although these events actually occurred as narrated they have all been disguised in such a way that it is not possible to recognise the firm in which they occurred or the people involved. Any apparent resemblance therefore to actual companies, firms or people is purely coincidental and has no basis in fact.

Jim Meredith is a university graduate aged 29, who has been five years in industry, the last two years of which he has been employed as a statistician in the economic and statistics department of the X.Y.Z. Confectionery Company, Limited.

His work brings him into daily contact with several executives of his own age, in the sales, advertising and planning departments of the company. They are all roughly of equivalent status, but only one of his colleagues is a university graduate.

Meredith does his work competently and is well thought of by his superiors. On the other hand he does not get on with his colleagues. None of them will lunch with him in the canteen if they can avoid it, and their constant complaint is that he " knows it all." The typists in the department have been heard to refer to him by a derogatory nickname.

The only adverse comment his superior makes about him is that when given a job to do, he always says that he is very busy and proceeds to emphasise the difficulties of the assignment, although he invariably completes the job to the satisfaction of his superiors.

Meredith's outside interests are invariably concerned with some form of public service or other, and in his locality he is prominent in a number of community activities. He is a very effective public speaker. He is self-confident, and ready to express his opinion on any subject, and does so in meetings before his colleagues (who should be much better informed on the subject under discussion) have had a chance to express their opinions.

He is a constant source of irritation to his colleagues, and apart from the implied criticisms he seems to make whenever he is discussing matters with them, they find him rather priggish.

In the opinion of the management Meredith is a very able young man who could go quite far, but his relations with his equals, and his priggishness, are likely to be considerable handicaps to him. He seems to be completely unaware of the irritation he causes his colleagues.

We are told that Jim Meredith is well thought of by his superiors; but does he know this, or do they find it too difficult to convey and make known their good opinion of him, either because they find him too irritating, are frightened that he might grow too big for his boots, or are careful not to show their favour to somebody who is not generally popular—a bad mixer?

Judging by the fact that Meredith has to emphasise the difficulty of his assignments and the amount of work he does—which we may call the " song and dance " attitude—he does not seem to be entirely confident that his performance is appreciated. He obviously needs recognition, which he obtains outside his work by public speaking and taking part in various local activities.

Everything his colleagues are objecting to—the " know it all " attitude, over-readiness to express opinions, and the critical turn of mind—may be no more than misguided and self-frustrating attempts on his part to gain recognition and popularity.

This interpretation is not as puzzling as it seems if we consider that at the university, readiness to express opinions and a critical attitude were quite likely to gain him recognition. Moreover, for three years prior to his present appointment, he was personal assistant to the chairman of a medium-sized company—a highly intelligent man who wanted Meredith's criticisms and valued his general knowledge and readiness to express opinions on any subject. It is easy to see, therefore, how the methods of approach and the personality characteristics which brought him success in his previous life have quite the opposite effect in his present job.

He seems to be unaware of the irritation he causes his colleagues, but he obviously senses general disapproval and notices that he is not as respected as he would wish. This makes him feel despondent, weak, inferior; he becomes anxious, needs reassurance, and tries hard to win sympathy and recognition by emphasising how busy he is and how difficult are his assignments. This, however, has completely the wrong effect. It creates more disapproval thus increasing his need for reassurance, and this in turn reinforces the " song and dance " attitude.

The case as described seems to indicate that he is caught up in another vicious circle. He needs recognition and he seems to have no difficulty in obtaining it in outside activities, especially through public speaking. This is likely to increase his ambition and to inflate his notions about himself, which leads to anticipation of jealousy among his colleagues. Consequently he adopts a hostile attitude towards them, even if this is disguised under a veneer of politeness. He feels they keep him down. He becomes unduly competitive as he feels he has to fight for recognition. He bolsters himself up by minimising and subtly or grossly disparaging others. Hence the " know it all " attitude about which his colleagues complain.

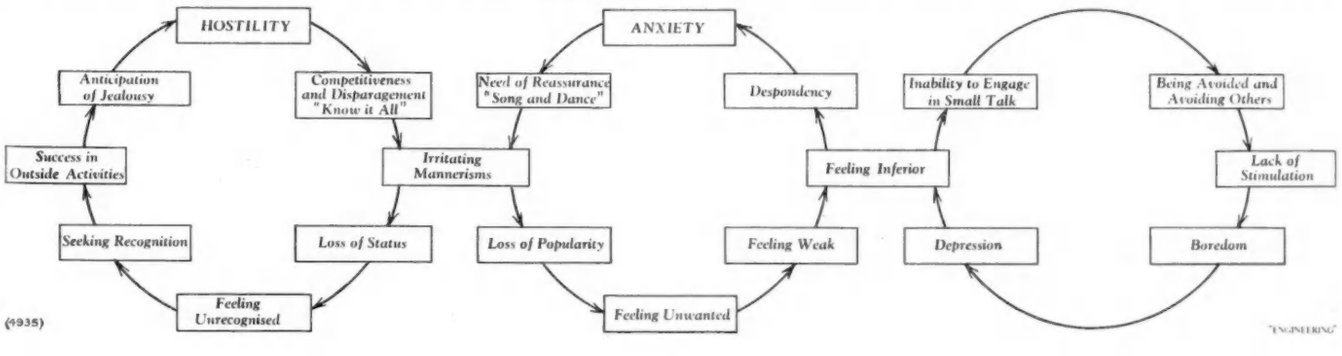
Over and above this there is likely to be a third cycle of circular causality. The chances are that he is not good at the small talk customary among his colleagues. He gets bored by it and, lacking stimulation, becomes depressed. He needs to gain attention and yet he cannot contribute to the conversation. This makes him feel inferior and to compensate he is driven to show off his knowledge and his cleverness. This increases his isolation.

What is the remedy? He was getting on well until his present job and he simply continues as before without understanding that circumstances have changed. If Meredith can be made to understand the intricate mechanisms which drive him more and more to lose the sympathy and appreciation of his colleagues, he might be better able to alter his approach. This is not easy but it can be done.

All this could be explained to his colleagues. Moreover, if they ceased to snub him, and to regard him as a young man without experience, and instead took some interest in him, his mannerisms would diminish and in due course disappear. However, such ideas may be difficult to drive home to people who have come up the hard way and to whom the man is a threat.

THEORETICAL ANALYSIS

We can represent these mechanisms diagrammatically. The block diagrams are a very crude approximation of the complicated psychological processes involved. One of the greatest obstacles to more accurate description is the exact meaning of the words used to describe the consecutive stages in the circuits. However, even if these words cannot yet be given an adequate definition, the verbal and diagrammatic descriptions can be generally accepted as true. It compares with many an individual's personal experience of the sequence and nature of his feelings. It also seems to sum up adequately many people's observations of others. Not everyone experiences in himself, or observes clearly in others, all the links in the process. Some of the stages in the diagrams pass unnoticed and one becomes aware of them only if one's attention is drawn



to them. This recognition may be difficult. It may be hard for a person to acknowledge and become fully aware of one of these stages in the circular process in which he is caught, even if this particular stage is obvious to everyone else. The more difficult it is to draw anyone's attention to, and to make him aware of, some particular link in the circuit, the more " unconscious " this link is.

Although we speak here of one feeling or experience *increasing* or *amplifying* another, it is very difficult to give any precise quantitative meaning to these terms. However, although their magnitude cannot be assessed or measured against any scale, the general trend of reasoning remains valid.

The important point to notice about our " vicious circles " is that they are positive feed-back circuits interlinked in such a way that the activity in any one of them increases the activity in others. Furthermore, these circuits have a very interesting peculiarity. A person who does not understand the nature of a circular process and who would like to achieve some specific result is likely, on common-sense grounds, to act in a way which may have precisely the opposite result.

Let us illustrate this by taking a simple example of a feed-back circuit, say a refrigerator. Anyone who does not understand the nature of the mechanism and who wishes, for example, to lower the temperature, may try to do so by inserting a quantity of ice. The effect of this will depend on the precise position in which the ice is placed. If located near the thermostat it will result in the thermostat being switched off permanently until the piece of ice is melted. It will thus lead to a raising, not a lowering, of the temperature in the main body of the refrigerator. We shall call such action, based on common sense coupled with lack of adequate knowledge of the mechanism, a *self-frustrating action* whenever it leads to an effect opposite to the effect desired.

Let us now return to Jim Meredith. Consciously or unconsciously, he acts in just such a self-frustrating manner. That he is avoided and that people are unwilling to listen to him is likely to increase his hostility and, since he badly needs recognition, it increases his anxiety, too. By augmenting hostility, anxiety and isolation, this fact contributes significantly to the amplifying process in the three main circles. Two common-sense remedies spring readily to mind—both are self-frustrating. One of them is a threat or a warning that if this state of affairs continues, Meredith will not be promoted. This is likely to increase his despondency and his anxiety, and so result in the " song and dance " attitude being intensified. Another common-sense remedy, a compliment or " boosting up," will have an effect similar to that of successful public speaking. He is likely to become even more critical of his colleagues. He may grow " too big for his boots," and become even more objectionable.

The ideal remedy would be to explain to him the intricate mechanisms which aggravate the situation. Failing that, if he is constructively criticised and encouraged at the same time, he is likely to feel less despondent but not unduly conceited. Anyone, and especially his superior, who shows personal interest in his progress will help to satisfy the basic needs giving rise to the circular mechanisms we have described. These needs are isolation and feelings of being unwanted and unrecognised. It will also remedy the lack of stimulation, and by its reassuring effect will minimise anxiety. By giving him a greater feeling of security the anticipation of jealousy will subside. This will lead to amelioration or removal of the irritating mannerisms which arise from undue competitiveness.

This approach is a further development of certain modern trends in personality theory and clinical psychology combined with some ideas familiar in the theory of automatic control mechanisms. The sources are discussed in the appendix at the foot of columns two and three on this page.

NOTICES OF MEETINGS

British Computer Society

LONDON
" The Physical Aspects of Xerography," by Dr. N. Levin. York Hall, Caxton Hall, off Victoria-street, Westminster, S.W.1. Mon., Jan 20, 6.15 p.m.

British Institution of Radio Engineers

LONDON
Discussion on " Mass Production of Television Tuners," to be opened by P. C. Ganderton. London Meeting. London School of Hygiene and Tropical Medicine, Keppel-street, Gower-street, W.C.1. Tues., Jan 7, 6.30 p.m.*

Chemical Society

EDINBURGH
Jubilee Memorial Lecture on " The Pattern of Research in the Electrical Industry," by Dr. H. K. Cameron. Edinburgh Branch. Royal Society of Edinburgh, 24 George-street, Edinburgh. Thurs., Jan. 9, 7.30 p.m.

Combustion Engineering Association

LONDON
Brains Trust Meeting on " Coal Price Structure." Southern Region. St. Ermin's Hotel, Caxton-street, S.W.1. Wed., Jan. 8, 10.30 a.m. (Not as previously announced.)

Engineers' Guild

EDINBURGH
Discussion on " Capital in Action," to be opened by J. Mackie. Luncheon Meeting. Scottish Liberal Club, Edinburgh. Mon., Jan 13, 1 p.m.

Helicopter Association

LONDON
" Boost Systems for Helicopter Gas Turbines," by Dr. A. W. Morley. Royal Aeronautical Society, 4 Hamilton-place, W.1. Fri., Jan. 10, 6 p.m.

Illuminating Engineering Society

LONDON
" Lighting of Aircraft Flight Decks," by J. W. Strange and B. Stevens. Federation of British Industries, 21 Tothill-street, S.W.1. Tues., Jan. 14, 6 p.m.
CARDIFF
" Lighting for Photography," by R. W. Unwin. Cardiff Centre. Offices of the South Wales Electricity Board, The Hayes, Cardiff. Thurs., Jan. 9, 7.30 p.m.
EDINBURGH
" The Sales Engineer's Approach to Lighting," by W. J. Burland. Edinburgh Centre. Y.M.C.A., 14 South St. Andrew-street, Edinburgh. Wed., Jan. 8, 6.15 p.m.

Incorporated Plant Engineers

LONDON
" A Practical Survey of Automatic Combustion Regulation on Industrial Boilers," by W. R. L. Kent. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Tues., Jan. 7, 7 p.m.*

Institute of Fuel

LONDON
" The Influence of the Adsorption of Frothing Agent on the Percentage Recovery of Coal from Flotation Pulps," by Dr. A. Jowett. Institution of Civil Engineers, Great George-street, S.W.1. Wed., Jan. 8, 5.30 p.m.*

Institute of Metals

BIRMINGHAM
" Production of Rods and Shapes in Copper and Its Alloys," by Dr. N. Swindells. Birmingham Local Section. College of Technology, Gosta Green, Birmingham. Thurs., Jan. 9, 6.30 p.m.
OXFORD
Junior Members' Evening. Discussion on " Seeing Dislocations." Oxford Local Section. Cadena Café, Cornmarket-street, Oxford. Tues., Jan. 7, 7 p.m.

Institute of Physics

LONDON
" Physical Research in the Research Group of the Atomic Energy Authority," by Dr. B. F. J. Schonland. London and Home Counties Branch. Wed., Jan. 15, 6 p.m.*
MANCHESTER
" Contact Electrification," by Dr. P. S. H. Henry. Manchester Branch. Bragg Lecture Theatre, The University, Manchester. Fri., Jan. 10, 6.45 p.m.

Institution of Civil Engineers

LONDON
" No. 1 Berth, Tilbury Dock, Port of London Authority," by C. Peel, A. J. Carmichael and R. F. J. Smeardon. Tues., Jan. 7, 5.30 p.m.*
Dugald Clerk Lecture on " Lifting Equipment," by W. R. Hockaday. Wed., Jan. 8, 6.30 p.m.*
BIRMINGHAM
" Engineering Research at the Building Research Station," by Dr. F. G. Thomas. Midlands Association. James Watt Memorial Institute, Great Charles-street, Birmingham 3. Thurs., Jan. 9, 6 p.m.

Institution of Electrical Engineers

LONDON
" The Breakdown of Transformer Oil under Impulse Voltages," by Dr. R. Hancox and Dr. H. Tropper. Measurement and Supply Sections. Tues., Jan. 7, 5.30 p.m.*
" Development of Variable-Speed High-Power Drives for Large Wind Tunnels," and " A Variable-Frequency Power Installation for Large Wind-Tunnel Drives," by P. McKearney, L. S. Drake and E. G. Mallalieu; " Speed Control of Large Wind Tunnels, with Particular Reference to the R.A.E. 8 ft. by 8 ft. High-Speed Wind Tunnel," by L. S. Drake, J. H. Fox and G. H. A. Gunnell; and " Data-Setting and Electrical Control Gear for the Flexible Nozzle and Diffuser of a High-Speed Wind Tunnel," by C. R. Dunham. Thurs., Jan. 9 5.30 p.m.*
Address by the President, T. E. Goldup. London Graduate and Student Section. Mon., Jan. 6, 6.30 p.m.*
BIRMINGHAM
" Electrical Equipment for Rectifier Locomotives," by H. Calverley, E. A. K. Jarvis and E. Williams. South Midland Centre. James Watt Memorial Institute, Great Charles-street, Birmingham. Mon., Jan. 6, 6 p.m.*
FARNBOROUGH
" Colour Television," by C. J. Stubbington. Southern Centre. R.A.E. Technical College, Farnborough. Wed., Jan. 8, 6.30 p.m.
LEEDS
Various short papers on " Transistors," by C. Adamson and L. M. Wedephol. North Midland Centre. Offices of the Yorkshire Electricity Board, 1 Whitehall-road, Leeds. Tues., Jan. 7, 6.30 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

British Computer Society, 29 Bury-street, St. James's, London, S.W.1.
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Combustion Engineering Association, 6 Duke-street, St. James's, London, S.W.1. (WHItehall 5536.)
Engineers' Guild, 78 Buckingham-gate, London, S.W.1. (ABBey 7315.)
Helicopter Association of Great Britain, 4 The Sanctuary, London, S.W.1. (ABBey 5160.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 12 The Parade, Solihull, Warwickshire. (Solihull 1111.)
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1. (LANgham 7124.)
Institute of Metals, 17 Belgrave-square, London, S.W.1. (BELgravia 3291.)
Institute of Physics, 47 Belgrave-square, London, S.W.1. (BELgravia 6111.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Highway Engineers, 47 Victoria-street, London, S.W.1. (ABBey 3891.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Naval Architects, 10 Upper Belgrave-street, London, S.W.1. (SLOane 4622.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Leeds Metallurgical Society. Apply to Dr. P. Feltham, The University, Leeds.
Newcomen Society, Science Museum, Exhibition-road, London, S.W.7. (KENsington 1793.)
North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-upon-Tyne 1. (Newcastle 20289.)
Sheffield Metallurgical Association, 66 Ringstead-crescent, Sheffield 10. (Sheffield 62144.)
Society of Chemical Industry, 14 Belgrave-square, London, S.W.1. (BELgravia 3681.)
Society of Instrument Technology, 20 Queen Anne-street, London, W.1. (LANgham 4251.)
South Wales Institute of Engineers, Park-place, Cardiff. (Cardiff 23296.)

APPENDIX

The nature of *circular determination* in character structure has been theoretically discussed by A. H. Maslow.[1 2 3] A similar idea was introduced, with less detailed treatment, by W. G. Allport[4] under the name of *functional autonomy*. The notion of *circular reflex*, foreshadowing the concept of *circular causality*, has been considered in some detail, as a mechanism underlying the establishment of early habits, by E. B. Holt.[5]

The idea of interconnected *vicious circles* operating in character structure was used for the first time by Karen Horney[6] and applied by that author with great force and lucidity to the analysis of a wealth of clinical material.[6 7 8] This theory has been recently elaborated and extended to the analysis of administrative behaviour of normal individuals within the setting of an organisation.[9 10 11]

Horney's theories were developed independently of cybernetics and information theory. The present approach, however, owes much to Wiener[12] and also to Tustin[13] who applied similar ideas, in a quantitative manner, to the analysis of economic systems.

The meaning of terms denoting various emotions, e.g., " anxiety," " hostility," " despondency," and the semantic problems raised by different attempts to define them have been discussed by several authors. A lucid exposition is provided by Reid.[14]

REFERENCES

[1] Maslow, A. H., " The Dynamics of Personality Organisation," *Psychological Review*, vol. 50, pages 514-539, 541-558, 194.
[2] Maslow, A. H., *Motivation and Personality*, Harper, New York, 1954.
[3] Maslow, A. H., " The Dynamics of Psychological Security—Insecurity," *Character and Personality*, vol. 10, pages 331-344.
[4] Allport, W. G., *Personality: A Psychological Interpretation*, Constable, London, 1937.
[5] Holt, E. B., *Animal Drive and the Learning Process*, 1931.
[6] Horney, Karen, *The Neurotic Personality of Our Time*, Routledge and Kegan Paul, London, 1937.
[7] Horney, Karen, *Our Inner Conflicts*, Routledge and Kegan Paul, London, 1945.
[8] Horney, Karen, *Neurosis and Human Growth*, Routledge and Kegan Paul, London, 1950.
[9] Tarkowski, Z. M. T., " Some Common Reasons for Inefficiency," *Personnel Management and Methods*, vol. 24, No. 208, pages 30-31, October, 1957.
[10] Tarkowski, Z. M. T., " The High Cost of Anxiety," *Personnel Management and Methods*, vol. 24, No. 209, pages 24-25, November, 1957.
[11] Tarkowski, Z. M. T., " A Better Understanding of Others," *Personnel Management and Methods*, vol. 24, No. 210, pages 22-23, December, 1957.
[12] Wiener, Norbert, *Cybernetics*, The Technology Press, New York, 1948.
[13] Tustin, Arnold, *The Mechanism of Economic Systems*, Heinemann, London, 1953.
[14] Reid, J. R., " Semantics and Definitions," an Introduction to: Cobb, Stanley, *Emotions and Clinical Medicine* Chapman and Hall, London, 1950.

LIVERPOOL
"British Columbia to Vancouver Island 138 kV Submarine Power Cable," by Dr. T. Ingledow and others. Mersey and North Wales Centre. Royal Institute, Colquitt-street, Liverpool. Mon., Jan. 6, 6.30 p.m.

Institution of Engineers and Shipbuilders in Scotland
GLASGOW
"Craneage in Works and Shipyards," by D. L. Nicolson. Tues., Jan. 14, 6.30 p.m.

Institution of Heating and Ventilating Engineers
LONDON
"Survey of Methods of Pressurisation for Medium and High-Pressure Hot-Water Systems," by J. R. Kell. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Thurs., Jan. 9, 6 p.m.*
NEWCASTLE-UPON-TYNE
"Air Filtration: Why and How," by G. H. Vokes. North East Coast Branch. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Tues., Jan. 7, 6.30 p.m.

Institution of Highway Engineers
NORWICH
"Steel: Modern Applications of Rolled Sections," by F. G. Ward. East Anglia Branch. Assembly House, Norwich. Tues., Jan. 7, 6.30 p.m.

Institution of Mechanical Engineers
LONDON
"Design and Development of Four Lightweight High-Speed Marine Gas Turbines for Electric Generator Drive," by A. W. Pope; and "Developments in Methods of Measuring Stresses in Compressor and Turbine Blades on Test Bed and in Flight," by D. A. Drew. Ordinary Meeting in conjunction with the Institution's Internal Combustion Engine Group. Fri., Jan. 10, 6 p.m.*
LOUGHBOROUGH
Annual General Meeting. "Numbers, Statistics and Computers in the Engineering Industry," by H. McGregor Ross. East Midlands Branch. Loughborough College of Technology, Greenclose-lane, Loughborough. Wed., Jan. 8, 7 p.m.
LUTON
"Pneumatic Suspensions for Motor Vehicles," by J. Sainsbury. Luton A.D. Centre. Town Hall, Luton. Wed., Jan. 8, 7.30 p.m.

Institution of Naval Architects
LONDON
Amos Ayre Lecture. "The Evolution of the Cargo Ship During the Last 35 Years and Some Thoughts on the Years to Come," by Dr. J. Ramsay Gebbie. Thurs., Jan. 9, 4.45 p.m.*

Institution of Production Engineers
CHATHAM
"Pneumatic Circuiting," by H. C. Orchard. Rochester Section. Sun Hotel, Chatham. Thurs., Jan. 9, 7.30 p.m.
LEICESTER
"The Use of Plastics in Industry," by B. E. Terry. Leicester Section. Grand Hotel, Leicester. Thurs., Jan. 9, 7 p.m.
LIVERPOOL
"Inspection as an Aid to Production," by W. Maiden. Liverpool Section. Exchange Hotel, Tithebarn-street, Liverpool 2. Wed., Jan. 8, 7.30 p.m.
STAINES
"Practical Approach to Engineering Fine Surfaces," by D. B. Ebsworth. Reading Section. Social Club, Petters Ltd., Staines. Thurs., Jan. 9, 7.30 p.m.

Institution of Structural Engineers
LONDON
"The Calculation of Bending and Torsional Effects in Girders," by J. S. Terrington. Thurs., Jan. 9, 6 p.m.*
MANCHESTER
"Shrinkage in Soils," by E. Ll. Morgan. Lancashire and Cheshire Branch. College of Science and Technology, Manchester. Tues., Jan. 7, 6.30 p.m.*
MIDDLESBROUGH
"Water Towers," by J. O. C. Ritchie. Northern Counties Branch. Joint Meeting with the Institution of Civil Engineers. Cleveland Scientific and Technical Institution, Middlesbrough. Wed., Jan. 15, 6.30 p.m.*

Junior Institution of Engineers
LONDON
"Brewing and Distilling," by T. F. Luck. Fri., Jan. 10, 7 p.m.*

Leeds Metallurgical Society
LEEDS
"Corrosion Problems and Water Treatment in Power Stations," by R. W. Wolforth. Chemistry Wing, The University, Leeds 2. Thurs., Jan. 9, 7.15 p.m.

Newcomen Society
LONDON
"Travel Diaries of Swedish Engineers of the Eighteenth Century as Sources of Technological History," by Michael W. Flinn. Wed., Jan. 8, 5.30 p.m.

North East Coast Institution of Engineers and Shipbuilders
NEWCASTLE-UPON-TYNE
"University Education in Marine Engineering," by Professor G. H. Chambers. Mining Institute, Newcastle-upon-Tyne. Fri., Jan. 10, 6.15 p.m.

Sheffield Metallurgical Association
SHEFFIELD
Annual General Meeting of the Methods of Analysis Group, and address by the new chairman of the Group. B.I.S.R.A. Laboratories, Hoyle-street, Sheffield. Tues., Jan. 7, 7 p.m.

Society of Chemical Industry
LONDON
"Stress Corrosion Cracking," by T. P. Hoar and J. C. Hines. Corrosion Group. Wed., Jan. 15, 6.30 p.m.

Society of Instrument Technology
LONDON
"Design of Cascade Control Systems," by R. L. Day. Control Section. Manson House, 26 Portland-place, W.1. Thurs., Jan. 9, 7 p.m.
BIRMINGHAM
"The Engineering Applications of the Precious Metals," by J. G. Want. Midland Section. Regent House, St. Phillip's-place, Colmore-row, Birmingham, 3. Fri., Jan 10, 7 p.m.
CHELTENHAM
Discussion on "Nickel Alloys for Instrument Production." Cheltenham Section. The Rotunda, Cheltenham. Tues., Jan. 7, 7.30 p.m.

South Wales Institute of Engineers
CARDIFF
"Some Aspects of the Design and Erection of Skyscraper Buildings," by L. G. Johnson. Thurs., Jan. 9, 6 p.m.

Companies in the News

Steel Sparkles

The leading steel companies have earned profits in 1956/57 (year ended September) almost universally higher than had been estimated at the half-way mark. Several of them paid out a higher dividend and ploughed back large sums to reserve. United Steel's trading profits, after charging over £3 million to depreciation, totalled £17·36 million compared to £12·05 million last year (£2·74 million to depreciation). South Durham Steel and Iron Company, Limited, who have made such advances in the quantity production of welded pipe, had an even better year. Profits rose by 59 per cent., from £3·22 million to £5·12 million. This company, now a major producer of heavy rolled products, should go from strength to strength during the coming year with demand at a high level from both the oil and the shipbuilding industries. Colville's trading profits are up by over 2½ million to £8·5 million after charging £2·8 million to depreciation, nearly three times the amount charged the previous year.

But the risk of re-nationalisation diminishes the attraction of potential high earnings. Meanwhile, Richard Thomson and Baldwins, who are likely to start building the industry's fourth strip mill quite soon, are still publicly owned. Up to £160 million will be spent over the next five to eight years.

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Centenary of Freeman, Fox and Partners

The latest firm of consulting engineers to achieve their centenary is Freeman, Fox and Partners of London, who were founded by Sir Charles Fox and his two sons, Charles Douglas and Francis, in 1857. Sir Charles had gained his early experience with Robert Stephenson on railway construction and had built up a successful contracting business with Joseph Bramah. His best-known work, however, was the Crystal Palace, the details of which he designed, for the Great Exhibition of 1851 in Hyde Park. According to C. M. Norrie, in *Bridging the Years*, Sir Charles gained a considerable reputation in financial circles by his shrewd opinions and, above all, by the success of the ventures which he controlled—many of them railway projects in Africa and South America.

The late Sir Ralph Freeman joined the firm in 1911 and became a partner in 1912. In 1922 the firm were retained by Dorman Long as consultants for the Sydney Harbour Bridge and the design was carried out by a separate staff under Freeman's direction. Since those days the firm have had a hand in several great bridges and were the first to use high tensile steel for such construction. The most recent of their bridges to be begun is that over Auckland Harbour in New Zealand; they have also been engaged recently upon designs for, among others, the Severn and Humber bridges. The Dome of Discovery for London's 1951 Festival of Britain and the civil engineering for at least two major C.E.A. thermal power stations have been among the firm's recent work at home. Work of a more unusual character on which they have been retained includes the Ffestiniog pumped storage scheme and the proposed radio-telescope for Sydney, Australia.

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Organising the Atomic Energy Authority

The White Paper on the organisation of the United Kingdom Atomic Energy Authority was published just before Christmas. The report is by the first of three committees appointed by the Prime Minister under the common chairmanship of Sir Alexander Fleck following the recent Windscale accident. Broadly, the recommendations involve the creation of a number of new senior technical posts in the Industrial Group, and the report goes on to say that these recommendations may involve the curtailment of some of the Authority's work in other directions.

The weakness in the present organisation of the Industrial Group comes primarily, in the opinion of the committee, from a lack of senior technical staff on the operation side, that is the part of the Industrial Group dealing with established plants like Windscale, Calder Hall and Capenhurst and which will soon have Chapelcross and Dounreay added to them. The committee consider that the pressure on the resources of the group have been too severe and that the Authority's development effort must be centred on fewer projects to provide the necessary switch in manpower. Such are the consequences of the present national shortage of highly qualified technical staff.

The report recommends the appointment of two deputy managing directors to the Industrial Group to assist the managing director, all three being substantially free from routine work. They also recommend that the board of management should include a temporary director for bringing about liaison with the other groups and with external organisations. There are certain other recommendations about the staffing of the branches and the headquarters unit. Particular attention should be paid, in the committee's opinion, to the organisational problems of Dounreay, and they recommend that a new director with a seat on the Group's board of management should be appointed to take charge of the site. Here, as in the investigation into the administration of the National Coal Board, the criticism from the Fleck committee is that the senior management is too thinly spread.

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Shipbuilders Undaunted

For the first time in its long and chequered history the shipbuilding industry appears unaffected, either materially or morally, by the severe and prolonged recession in freight rates and shipping activity. There has been a slowing down of the order inflow; there have been some cancellations; but these factors have only tidied up what in fact was a grossly inflated order position. The industry is going ahead with expansion and modernisation plans and can expect a substantial recovery in shipping activity long before order books become seriously depleted. The trouble with the shipping world is not so much an over-supply of ships as too great a proportion of uneconomic ships, most of which have been written off many times over during the boom years. It is for this reason that so many shipowners are content to keep their names in the queue at their favourite shipyards despite what is likely to be a poor year of trading.

The annual report of Austin and Pickersgill Limited, the shipbuilding group formed recently in Sunderland, shows most encouraging results and the kind of impact which can be expected from the injection of capital and a vigorous modernisation programme. Both Austin and Pickersgill were old established family concerns which had remained small by shipbuilding standards. Their acquisition and amalgamation during the year, by a consortium which includes one of the most progressive shipowning companies in the world, London and Overseas Freighters, a firm of investment bankers. Philip Hill, Higginson and Company and Lambert Brothers (who are leading shipowners and exporters of coal and oil) may yield benefits.

The results of the change in ownership have been spectacular even in the first few months. Profits are up by nearly £60,000 to £194,000 before tax.

Atomic Review

Looking Forward

1958 is likely to be a dramatic and critical year in the development of atomic energy. A number of events can already be foreseen. Experimental evidence may be published that controlled thermonuclear reactions have been achieved for the first time. Construction of the first British particle accelerator to generate a concentrated beam rated at several thousand million electron volts will also be put in hand. Britain's first fast-fission power-reactor experiment is due to start operating in the spring; and the study of high-temperature ceramic-fuelled reactors is likely to capture increasing interest, though their use in conjunction with closed-cycle gas turbines may be rather more distant. The confidence created by the first overseas order for a gas-cooled nuclear power station (received from Italy at the end of last year) may lead to further orders in Europe and the Far East. The evaluation of the Windscale accident by the committees under the chairmanship of Sir Alexander Fleck may lead to a number of salutary developments. In particular steps may be taken to attract more technically qualified people into the nuclear field. There may also be less flirtation with ingenious but unsound reactor systems and greater concentration on the hard engineering work of technical development. Almost certainly, new and striking uses for radioactive isotopes and nuclear radiations will be discovered. The year will be graced too by the second major exchange of nuclear information, when representatives of many nations meet for the 1958 International Conference on the Peaceful Uses of Atomic Energy. It is therefore an appropriate time to consider the direction which nuclear development is taking. The contributors to the following symposium discuss various aspects of nuclear work, with special reference to the future. Other contributions on controlled thermonuclear reactions, radioactive isotopes, and related topics are to be published at a later date.

REACTOR TECHNOLOGY

By Professor J. M. Kay

It is well known that the number of *possible* types of nuclear reactor is very large. This has often caused speculation as to which particular types are likely to be most successful for commercial power production in the future. It has sometimes been imagined that some marginal advantage of a purely scientific and calculable nature can decide the issue in any competition between one type of reactor and another. This belief, however, is in fact an illusion. It fails to take account of the vast extent of the engineering design and development effort, and of the cumulative constructional and operational experience required, before any new type of power plant can become firmly established in the heavy engineering field.

Perhaps the most significant change during the last year or so has been the gradual realisation that the number of *different* types of nuclear reactor ever likely to reach the commercial stage will be very small. There are in fact only two types of reactor which at the present time may be regarded as definitely established for power generation. First and foremost is the gas-cooled graphite-moderated natural-uranium reactor which shows to the greatest advantage when built in very large sizes for base-load duties. It now seems unlikely that any other type will displace the gas-cooled reactor within the foreseeable future in cases where more than 100 MW electrical output is required from a single reactor. For sizes of 200 MW and upwards the gas-cooled reactor should be immediately competitive in many parts of the world with conventional thermal stations burning either hard coal or imported oil. As with previous types of power plant, the gas-cooled nuclear reactor will undergo a process of steady and progressive development towards larger sizes, higher temperatures and efficiencies, and lower costs of generation, but this is essentially the normal procedure of engineering evolution. The official United Kingdom policy of concentrating the massive engineering resources of the main industrial groups on this one type of reactor in the first instance is undoubtedly a wise one.

The only other type with an immediate application is the pressurised-water reactor. This is essentially a power plant of restricted application, most suitable for small or moderate sized installations from 10 MW up to about 50 MW electrical capacity. Within this bracket the pressurised-water reactor may have a useful field of application, not in undeveloped countries as is sometimes suggested, but rather in certain isolated industrial areas where conventional fuel costs are high and where the comparison will normally be made with a Diesel installation. Depending, as it must, on a supply of enriched fuel, the pressurised-water reactor suffers a serious disadvantage when compared with natural-uranium reactors. The position might be very different in a few years time, however, if the technical problems of using plutonium as the fissile material in the fuel charge could be solved. It remains to be seen whether the United Kingdom Atomic Energy Authority policy of studiously ignoring this type of reactor for small-sized power plants will prove in the long run to have been right.

What of the other possibilities? The high-temperature gas-cooled reactor should be regarded as a normal development from the existing design rather than a distinct type in its own right. A note of caution, however, should be sounded on this matter of higher temperatures. Progress will be slow and difficult and there can be no question of advancing quickly to working temperatures higher than about 600 deg. C. Perhaps the most important alternative in the gas-cooled category, particularly at the lower end of the power range, is the heavy-water moderated gas-cooled type. This could be a useful partner to the graphite-moderated reactor.

As alternatives to the pressurised-water reactor, mention should be made of the boiling-water reactor and also of the organic-liquid moderated reactor. In neither case, however, have the engineering or chemical problems been resolved. Of the other so-called "advanced reactors" it seems increasingly probable that schemes for sodium-graphite, liquid-metal-fuelled, and aqueous homogeneous reactors will sooner or later die a natural death. It is difficult to see any justification for diverting further research and development effort in the United Kingdom on to any of these types.

Finally, we have the fast breeder reactor. Much has already been written about the engineering problems of the fast reactor. With the approach to completion of the Dounreay project these previously academic problems have acquired a new aspect of reality and urgency. The results of this first full-scale fast reactor experiment will be awaited with the utmost interest, but in the meantime it is probably better to reserve judgment on the ultimate application of this type of plant.

PROPULSION

By Dr. J. V. Dunworth

The outstanding achievement of nuclear power in the field of transport in the last ten years has been the construction of the American nuclear powered submarine Nautilus, which, in theory, can travel submerged at speeds of the order of 20 knots for several months. The crucial factor in nuclear power which makes this possible is that the weight of fuel required for such an operation is negligible. In fact only a few pounds will be consumed in giving the performance just described. The second factor is that although the weight of shielding in a nuclear reactor is considerable, this weight can be reduced significantly if a reactor can be designed without paying special attention to securing financial economy of operation. A submarine is sufficiently large to accommodate an adequate weight of shielding under these conditions. Finally, a nuclear powered submarine does not involve any very serious hazard from the highly radioactive waste products generated in a nuclear reactor since the vessel is likely to sink if it is damaged and the resulting contamination of the water would in most cases be quite tolerable.

To secure greater economy of operation, it is likely that a commercial reactor would have to be somewhat larger and more extensively shielded. Such a procedure is practicable in ships of the order of ten thousand tons and upwards and consideration is being given in many countries to the possible design of oil tankers, ore carriers and large passenger liners. The passenger cargo liner Savannah is being constructed in the United States and will use a pressurised-water reactor which is based on the same technology as the reactor used in the Nautilus. A variant of this reactor system is obtained by using an organic liquid as the coolant and moderator and this has considerable advantages in that the coolant is at much lower pressure. Studies have been proceeding in the United Kingdom for some time on this reactor system while a small land-based experimental system has been built in the United States.

For the large ship it may be possible to scale down a Calder Hall type reactor while consideration has been given in several countries to a gas-cooled heavy-water moderated system. No other reactor system at present appears likely to be the basis of power in commercial shipping on an appreciable scale in the next fifteen to twenty years.

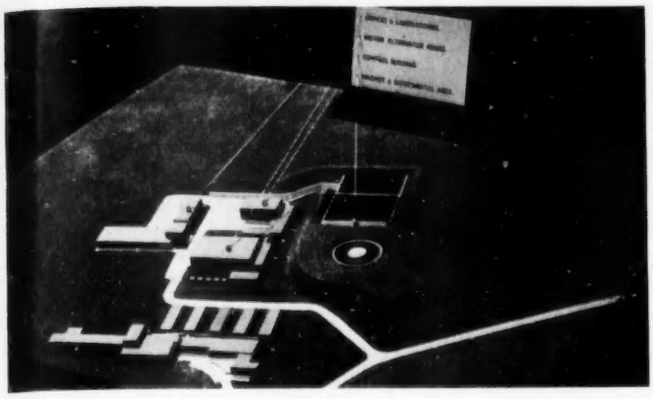
Schemes have been suggested to make use of nuclear power in a gas-turbine but the first commercial prototype reactor is likely to be at least ten years off and on safety grounds there may be considerable objections to ship use.

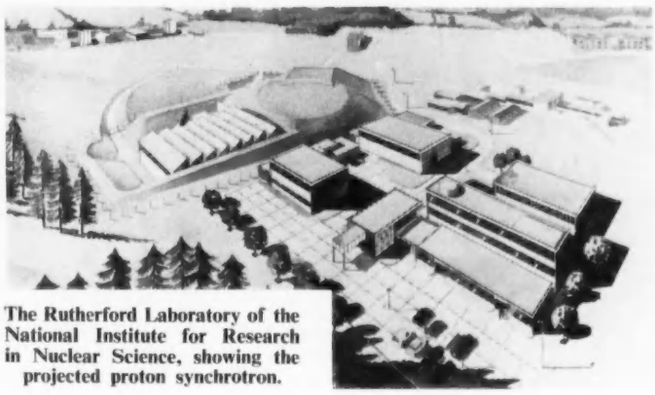
The U.S.S.R. has launched a 16,000 ton, 44,000 s.h.p. ice-breaker which should have virtually unlimited range. This appears to be a peculiarly suitable use of nuclear power for ship propulsion. It is expected that the ship will be able to navigate through 6 ft. of ice.

The use of nuclear power for land or air transport does not appear to hold out much promise. It is technically possible but the large weight of shielding would result in a heavy unit. The minimum capital cost for a power reactor of roughly one million pounds rules out small-scale applications. The unlimited range which nuclear power affords does not appear to offer any significant advantage except perhaps for a military aircraft, a very small number of the world's commercial aircraft, and land tractors for use in extremely remote areas.

Contributors

The four contributors to this symposium are all eminent in the atomic energy field. Professor J. M. Kay, A.M.I.Mech.E., A.M.I.Chem.E., is Professor of Nuclear Power in the Department of Mechanical Engineering at Imperial College, South Kensington, London, S.W.7. Dr. J. V. Dunworth, C.B.E., M.A., is Head of Reactor Division, Research Group, United Kingdom Atomic Energy Authority. Mr. J. A. Jukes, M.A., B.Sc.(Econ.), is Economic Adviser, United Kingdom Atomic Energy Authority. Dr. T. G. Pickavance, B.Sc., is Director of the Rutherford High Energy Laboratory of the National Institute for Nuclear Research, being built near Harwell.





The Rutherford Laboratory of the National Institute for Research in Nuclear Science, showing the projected proton synchrotron.

EXPORTING REACTORS

By J. A. Jukes

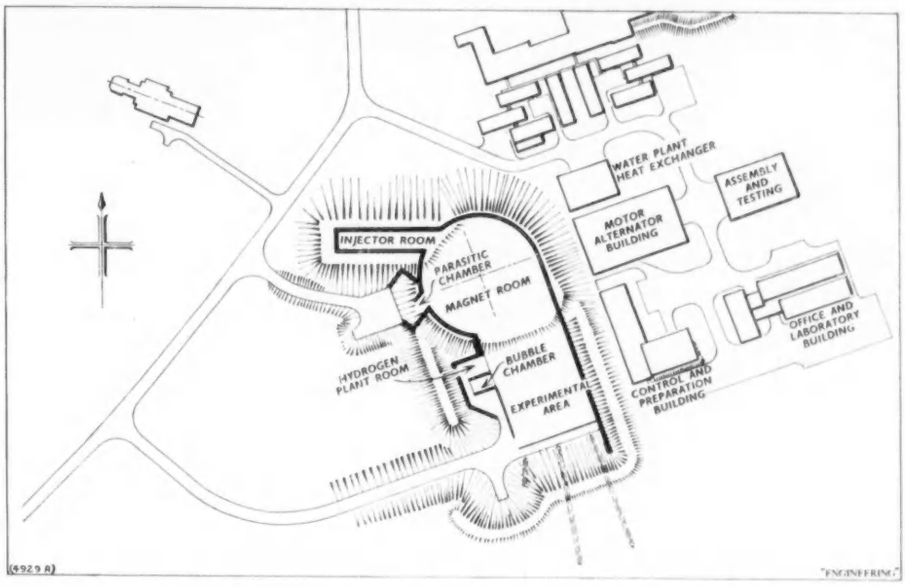
British industry has for generations been a leading exporter of capital goods and particularly of heavy electrical plant to countries throughout the world. It is rapidly developing its capacity to design and construct complete nuclear power stations and is therefore now looking seriously at the potential export market. British firms are gaining invaluable experience at home through Britain's own nuclear power programme, which is supported by a large programme of research and development in the United Kingdom Atomic Energy Authority.

Britain's first power reactors for export will be of the same type as those in the home programme, that is, developments of Calder Hall. Their output capacities will be large—probably over 60 MW—because the gas-cooled graphite-moderated reactor used at Calder Hall offers important economies of scale. The first overseas customers are therefore likely to be those industrialised countries having an integrated electricity distribution system which can absorb a fairly large base load. As nuclear power stations have high capital, but low running costs, the existence of adequate capital and the prevailing level of interest rates are important. Various inquiries by possible purchasers have already been received; they have come mainly from Western European countries, some of the more advanced Commonwealth countries and Japan. In addition to the inquiries, a letter of intent for the purchase of a nuclear power station, a 200 MW plant, has been received from AGIP Nucleare of Italy by the Nuclear Power Plant Company. The arrangements include provision for the exchange of design information under licence. Tenders by British firms are also likely to be submitted for a second nuclear station in Italy. These are for the 150 MW station which is the subject of a study now being carried out by the World Bank on behalf of SENN (Societa Elettronucleare Nazionale). A purchasing mission from Japan is also coming to Britain in the near future. There have been many other inquiries from possible purchasers in a wide range of countries; at the present time negotiations are most advanced with purchasers in Western Europe. Many of the more industrialised countries will wish to build their own reactors and may decide to build to British designs under licence; this trend is already visible in the AGIP Nucleare arrangements.

The United Kingdom Atomic Energy Authority are both willing and able to supply fuel and to process irradiated fuel elements for reactors exported by British firms. Arrangements for the provision of these services were included in the agreement recently signed with Italy. In due course the supply and processing of nuclear fuels to overseas countries may become an important export trade; fuels may be processed for other industrial countries which build the reactors themselves.

The provision of medium and small capacity power reactors, say of 30 MW and less, may eventually form an important part of exports, especially to less developed countries. However, the development of suitable reactor systems will take a long time. The research programme of the Atomic Energy Authority includes the study of small reactors, including a scaled-down Calder Hall type of reactor, the heavy-water gas-cooled and the organic liquid reactors.

The export of research reactors and materials testing reactors, though less spectacular in terms of value than that of power reactors, is also a useful market. British firms are offering two types for export. High-flux 10 MW DIDO type materials testing reactors are under construction by Head Wrightson Processes Limited in Australia and Denmark and the firm is also supplying the design and major components for a similar reactor in Western Germany. The MERLIN pool type reactor is provided by A.E.I.—John Thompson Limited and one is on order for Western Germany.



HIGH ENERGY ACCELERATORS

By Dr. T. G. Pickavance

Higher energy and higher intensity are both being developed in the design of particle accelerators. The present energy record is 10 GeV in the 36,000 ton Russian proton synchrotron, but it is unlikely that much larger machines of this constant-gradient type will be built since the magnet weight increases rapidly with energy. The new 7 GeV proton synchrotron under construction at Harwell for the National Institute for Research in Nuclear Science is being designed for high intensity operation. The 25 GeV Brookhaven and C.E.R.N. machines use alternating-gradient focusing to compress the beam into a smaller space, and have 4,000 ton magnets. A similar 50 GeV machine is planned in the U.S.S.R. Tolerances are tight (e.g., $\pm$ 0·3 mm. on a 100 metre radius magnet), and the practical limit may not be very far away.

The energy liberated when very energetic particles collide with stationary particles increases only as the square root of the bombarding energy, and a 100 GeV proton gives up only about 12 GeV. If two 20 GeV particles collided head on, 40 GeV would be released—equivalent to a bombarding energy of about 1,000 GeV with the struck particle at rest. Attempts are being made in the United States to develop designs for a colliding-beam accelerator; very high intensities are needed for a useful rate of collision. A direct-current magnet is used, to avoid the intensity limitation of magnet pulsing, but the field must vary rapidly with radius to keep the accelerating particles in the ring. The strong de-focusing produced by such fields is overcome by spirally ridging the magnet poles or by reversing field direction in alternate sectors. A reverse-field machine could contain particles rotating in opposite directions, performing "scalloped" orbits which intersect at intervals around the magnet. An alternative scheme would inject alternate pulses from a normal machine into an interlocking pair of direct-current storage ring magnets. Many fundamental problems remain to be solved, and these machines are some time away.

The spiral-ridge scheme may be used with cyclotrons, to eliminate frequency modulation and thus to give high intensity by achieving continuous operation. These machines are very promising for proton energies less than 1 GeV, and will probably be constructed when existing snags have been overcome.

Another development would be to exploit the

Continuing Atomic Review

intense fields near particles in a plasma. Ideas have been proposed, but a practical high-energy machine is still far away. A " break-through " here could be of great importance.

Electron accelerators are also important, and a 7 GeV alternating-gradient synchrotron is being built in America; others are contemplated. Much higher energies would be hard to get; 7 GeV electrons radiate several MeV per orbit in the American machine, and the energy radiated increases as the cube of the electron energy for a given magnetic field. Linear accelerators do not suffer from this defect, and there is an American design study for a 100 GeV electron machine two miles in length.

Perhaps one day a new energy record will not be followed by important discoveries, but the surface of existing fields has scarcely been scratched. Refinements of accelerator performance and experimental technique will certainly continue everywhere.

General Notes

Provisional Agenda for 1958 Geneva Conference

A provisional topical agenda for the 1958 International Conference on the Peaceful Uses of Atomic Energy, to be held in Geneva, has now been published, and is as follows:

GENERAL SESSIONS

Session A Opening of Conference.
Session B The Future of Nuclear Power.
Session C Experience with Nuclear Power Plants.
Session D Plans for Construction of Nuclear Power Plants.
Session E.1 The Use of Nuclear Energy for Purposes Other than the Generation of Electricity (Propulsion, Space Heating and the Direct Use of Radiation).
Session E.2 Progress in the Use of Isotopes.
Session F.1 Operational Experience in Health and Safety.
Session F.2 Recent Developments in Fundamental Physics.
Session G Possibility of Development of Controlled Fusion Reactors.

CLOSING SESSIONS

Session Y (*a*) Development of International Collaboration in the Fields of Atomic Energy in the Last Few Years.
(*b*) Supply and Training of Technical Personnel.
Session Z Closing of Conference.

PARALLEL TECHNICAL SESSIONS

(*Series* 1)

Session 1-1 Reactor Technology I.
Session 1-2 Reactor Technology II.
Session 1-3 Basic Applications of Chemistry in Atomic Energy I.
Session 1-4 Basic Applications of Chemistry in Atomic Energy II.
Session 1-5 Properties of Reactor Materials I.
Session 1-6 Properties of Reactor Materials II.
Session 1-7 Properties of Reactor Materials III.
Session 1-8 Processing of Irradiated Fuel Elements I.
Session 1-9 Processing of Irradiated Fuel Elements II.
Session 1-10 Treatment of Radioactive Wastes I.
Session 1-11 Treatment of Radioactive Wastes II.
Session 1-12 Handling of Highly Radioactive Materials.
Session 1-13 Experience in Radioactivity Problems Arising from the Operation of Reactors and Chemical Plants.

(*Series* 2)

Session 2-1 Problems in Nuclear Fusion I.
Session 2-2 Problems in Nuclear Fusion II.
Session 2-3 Problems in Nuclear Fusion III.
Session 2-4 Physics of Elementary Particles.
Session 2-5 Physics of Fission.
Session 2-6 Nuclear Data I.
Session 2-7 Nuclear Data II.
Session 2-8 Reactor Theory and Calculations I.
Session 2-9 Reactor Theory and Calculations II.
Session 2-10 Fuel Cycles and Economics of Nuclear Power I.
Session 2-11 Fuel Cycles and Economics of Nuclear Power II.
Session 2-12 Prototype Power Reactors.
Session 2-13 Use of Research and Test Reactors I.
Session 2-14 Use of Research and Test Reactors II.
Session 2-15 Reactor Experiments I.
Session 2-16 Reactor Experiments II.

(*Series* 3)

Session 3-1 Dosimetry and Standards.
Session 3-2 Technological Applications of High-Intensity Ionising Radiation I.
Session 3-3 Technological Applications of High-Intensity Ionising Radiation II.
Session 3-4 New Uses of Isotopes in Medicine I.
Session 3-5 New Uses of Isotopes in Medicine II.
Session 3-6 Use of Isotopes in Biology and Physiology.
Session 3-7 Use of Isotopes in Research, Control and Industrial Technology.
Session 3-8 Use of Isotopes in Agriculture.
Session 3-9 Radioactive and Stable Isotopes Production and Distribution.
Session 3-10 Biological Effects of Radiation I.
Session 3-11 Biological Effects of Radiation II.
Session 3-12 Experience in Radiological Protection I.
Session 3-13 Experience in Radiological Protection II.
Session 3-14 Reactor Safety and Location.
Session 3-15 Oceanographic Meteorological Aspects of the Large Scale Use of Atomic Energy.

(*Series* 4)

Session 4-1 Raw Material Supplies.
Session 4-2 Raw Material Supplies.
Session 4-3 Raw Material Supplies.
Session 4-4 Ore-Dressing, Extraction and Refining of Uranium and Thorium I.
Session 4-5 Ore-Dressing, Extraction and Refining of Uranium and Thorium II.
Session 4-6 Methods of Separation of Isotopes I.
Session 4-7 Methods of Separation of Isotopes II.
Session 4-8 Methods of Separation of Isotopes III.
Session 4-9 Fabrication of Fuel Elements I.
Session 4-10 Fabrication of Fuel Elements II.
Session 4-11 Processing of Other Materials Useful in Atomic Energy I.
Session 4-12 Processing of Other Materials Useful in Atomic Energy II.

U.K. Instruments at Geneva

The Scientific Instrument Manufacturers Association of Great Britain (SIMA) has booked a 5,000 sq. ft. area for participation in the second Atoms for Peace Exhibition to be held in September this year at Geneva. This move is backed by 25 member firms of the Association, and the Association has appointed Industrial Exhibitions Limited to be its organising and co-ordinating authority for this project, which forms a large part of the overall British nuclear engineering display being arranged by the Nuclear Energy Trade Associations' Conference (NETAC), of which SIMA is a founder member. The SIMA exhibit will consist of a large central inquiry and general display stand surrounded by the separate stands of British nuclear instrument and control equipment manufacturers.

United Kingdom Delegate to C.E.R.N.

Dr. H. W. Melville, F.R.S., Secretary of the Department of Scientific and Industrial Research, was appointed by the United Kingdom Government to succeed Sir Ben Lockspeiser, K.C.B., F.R.S., at the end of last year as one of their delegates to the Council of the European Organisation for Nuclear Research (C.E.R.N.). Sir Ben, who, until the end of 1957, was also President of the Council of C.E.R.N., retired from the United Kingdom public service in March, 1956, and has now asked to be relieved of his responsibilities as a Council member.

The other United Kingdom delegate to C.E.R.N. is Sir John Cockcroft, O.M., K.C.B., C.B.E., F.R.S. The D.S.I.R. is the department responsible in the United Kingdom for C.E.R.N. affairs, and for including the necessary financial provision on its vote. The United Kingdom contribution is 25 per cent. of the total. In 1957 this amounted to some £1,240,000, but 1957 was probably the year of greatest expenditure for it included much capital outlay on the 600 MeV synchro-cyclotron and the 25 GeV proton synchrotron. The smaller accelerator is now complete and the larger is due for completion in 1960.

The staff of C.E.R.N. is recruited mainly from member countries, of which there are twelve. Some 20 per cent. of the senior staff are United Kingdom nationals. The intention is that the great majority of the scientific staff shall be on relatively short-term appointments in order to secure the maximum flow of scientists through the laboratories. The cost of buildings and equipment when completed is estimated to be about £15 million. Orders for equipment and other items, placed in this country so far, total about £500,000. These comprise a wide range of engineering, electrical and other laboratory apparatus, including a linear accelerator supplied by the Metropolitan-Vickers Electrical Company and a large computer by Ferranti's.

Nuclear Power Groups

The table of United Kingdom consortia engaged in atomic-energy work, which was published in Atomic Review last November 29, requires revision. The head office of the A.E.I.—John Thompson Nuclear Energy Company, Limited, is now located at Radbroke Hall, Knutsford, Cheshire.

In addition, though reference was made to the previous work of Taylor Woodrow in the section on the English Electric—Babcock and Wilcox—Taylor Woodrow group, there was no mention of the considerable contribution already made by Babcock and Wilcox Limited. As will be well known, Babcock and Wilcox have some 10 years experience in this field, and were responsible for the design and construction of the steam-raising plant for both the Calder Hall and Chapelcross nuclear power stations, comprising 32 heat exchangers, and for the ancillary equipment. In due course a revised list of consortia will appear in Atomic Review.

West German Nuclear Energy Programme

Last month the West German Government's Atomic Energy Commission approved an eight-year nuclear reactor programme for completion in 1965. It is reported that the cost of the programme will be in the region of from D.M. 2,200 million to 2,400 million (about £200 million) and be raised jointly by the Government and industry.

Reactor Data Service

G. C. Dewey and Co., Inc., of 19 West 44th-street, New York City, announce the formation of a new department of nuclear science and engineering. The corporation has been engaged for the past several years in weapons-system analysis and operations research for government and industry. The new department represents a logical expansion based on the corporation's military work in the nuclear field. The department has been organised to provide industry with analytical data in the reactor field. The staff of the department are qualified to make calculation of nuclear cross-sections, radiation dosage, radiation shielding, reactor critical mass, reactor flux, reactor control, reactor constants, and parametric reactor studies.

Boiling Water Reactor for U.S. Group

Mr. Lewis L. Strauss, Chairman of the United States Atomic Energy Commission, has announced that the Commission has signed a contract with the Northern States Power Company, Minneapolis, Minnesota, for the development, construction and operation of a large-scale nuclear power plant. Reference to the project was made in Atomic Review last April 12. The contract provides that the Northern States Power Company will build at its own expense a nuclear power plant of an advanced boiling-water type, incorporating large-volume controlled recirculation of the water coolant-moderator. The reactor will be fuelled with slightly enriched uranium. The plant, which is to be located at a site provided by the utility company in its system, will have a net electrical capacity of 66 MW. Under the contract the company will operate the plant for five years. The total estimated cost of the project, including cost of research and development, is about 28 million dols. The Commission will contribute 6 million dols. towards the research and development work, most of which will be performed in private facilities. In addition, the Commission will waive fuel use charges up to 1 million dols.

The Northern States Power Company has under consideration a South Dakota site on the Big Sioux River, north-east of the company's present steam electric generating station in Sioux Falls, South Dakota. The Northern States Power Company and ten other Midwest electric utility companies have formed a non-profit corporation known as Central Utilities Atomic Power Associates (C.U.A.P.A.). The ten other companies in the group will contribute a total of 3,650,000 dols. towards the research and development costs. In return the companies will receive technical information developed in the project and their personnel will receive training in nuclear power plant technology. The Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin, will be the principal sub-contractor for research and development, fabrication and construction of the reactor. It is expected that the reactor will be completed by June, 1962.

Submarine Tanker

It was reported last month that Gel Tankers (London) have been considering the construction of a 68,000 ton d.w. nuclear-propelled submarine tanker, and have commissioned a Geneva company of naval architects to undertake a preliminary study. The advantages and disadvantages of such a vessel have been discussed previously in Atomic Review (June 1, 1956) and on page 738 of last December 13.

Special Article

ENGINEERING CENTENARIES OF 1958

It is a debatable point, in reviewing engineering centenaries, whether to begin with the men whose births, deaths or works fall to be commemorated or with the works for which they were responsible. As it chances, however, in the present instance, some of those works were of such outstanding significance that to give them priority would appear to be justified; and, though the onward march of science was notable in many directions 100 years ago, public attention was focused at that time, perhaps, more on maritime developments than on any other, with the possible exception of the first Atlantic telegraph cable, so that it is convenient to start with ships, and more particularly with shipbuilding.

Among the vessels which made history in 1858, easily the most prominent in the public mind as well as in size was the Great Eastern. Towards the close of the previous year I. K. Brunel and John Scott Russell had tried, and failed, to launch her, and were actively engaged, with the aid of Tangye's hydraulic jacks, in moving her towards the water, foot by foot, in readiness for the spring tides of January, 1958; and on the 31st of that month they did succeed at last in floating her. She was then towed to the moorings already prepared off Deptford, where she was fitted out—very slowly, for the cost of launching her had exhausted the available funds. She was completed for sea in the following year.

While Brunel and Scott Russell were thus wrestling with the problems of the largest vessel in the world, John Laird, at Birkenhead, was constructing one of the smallest, a launch for Livingstone's expedition to the Zambesi River. She was named Ma Robert—the African natives' name for Livingstone's wife—and was remarkable in several ways. One was the rapidity of her construction, for, though work on the hull and engine only began on January 4, 1858, the engine was under steam on February 6 and the completed vessel was loaded on board H.M.S. Pearl for shipment to Africa on April 3. She was more notable, however, as being the first vessel to be built of steel—described by a contemporary chronicler as "'steel plates' or the patent homogeneous metal manufactured by Messrs. Shortridge, Howell and Jessop, of Sheffield." The hull was built in three sections, each separately watertight, to be joined together afloat, and was 75 ft. long, 8 ft. beam and 3 ft. deep. The 12 h.p. engine was in the centre section and drove paddles. Livingstone reported favourably on her performance at first, but she was not a success. Before long he had nicknamed her the "Asthmatic," and within the year had petitioned the Government for another vessel.

Concurrently, a revolution was proceeding in warship design, for it was in March, 1858, that the French Government initiated a programme for the construction of four ironclads: the Gloire and Invincible at Toulon and the Normandie at Cherbourg to be built of wood, iron-plated, and the Couronne at L'Orient, to be of iron throughout. The Gloire was the first to be completed—an ugly barquentine-rigged craft, only 252 ft. long, but armoured from end to end with a waterline strake of 4⅝ in. plates and above it a strake 4½ in. thick, both backed by 26 in. of timber. She carried an armament of 36 5-ton guns and shares with only one other warship—the Dreadnought of half a century later—the distinction of having made the battle fleets of all other nations obsolete at a stroke.

One other ship of 1858 deserves mention, the first of Walter Winans's freak "cigar ships"; pointed at both ends and of circular section throughout, and intended to be propelled by an annular paddle which encircled the hull at midlength. She was launched at Baltimore, Maryland, on October 6, 1858, but was a failure.

Dock construction was proceeding in the United Kingdom also, both for the Government and private account. In January, 1858, a 500 ft. graving dock was completed on the Clyde at Partick for the then well-known firm of Tod and McGregor. Later in the year another was added to the resources of Chatham Dockyard; and on December 17, 1858, the water was admitted to the 50 acres of Tyne Dock, between Jarrow-on-Tyne and South Shields, constructed by the North Eastern Railway primarily for the outward shipment of coal, but now finding a new purpose in the inward shipment of iron ore. It was an earnest of further developments that, on January 5, 1858, the first meeting was held of the Mersey Docks and Harbour Board; just 200 years after Liverpool had managed at last to become independent of Chester in matters of maritime trade, for until 1658 it was to the port of Chester that Mersey Customs dues were payable.

From ships and ports to navigation is a natural transition. Throughout 1758 John Smeaton was engaged in placing the stonework of the Eddystone lighthouse—a slow business in the early stages, as his men could work only for a few hours at a time; but he was establishing a policy which was still being actively pursued 100 years later. It was in 1858 that the Bishop Rock lighthouse first showed its light. In the same year work began on the St. Abb's Head lighthouse, Berwickshire; and, a development of great importance, that electric light was first used in a coastal lighthouse; the installation at the South Foreland in 1858 being the first to guide ships at sea.

This was an achievement for electricity, but a more striking one, from the popular standpoint, was the establishment of telegraph communication across the Atlantic. The first attempt, in 1857, had failed, but the same ships tried again in 1858, H.M.S. Agamemnon being lent by the Royal Navy and the U.S.S. steam frigate Niagara by the United States Government. Among the ships in attendance was H.M.S. Gorgon, distinguished by having a type of main engine that is still known by her name. It was designed by John Seaward, who founded the firm of Seaward and Capel; he died on March 26, 1858.

The two halves of the cable were spliced in mid-ocean on July 29, and by the evening of August 5 both ends were landed. The first message, as distinct from mere signals, was sent from England to the United States on August 16: "Europe and America are united by telegraphy. Glory to God in the highest, on earth peace, goodwill towards men.!" Great rejoicings followed on both sides of the Atlantic, and the banquets and complimentary speeches were still taking place until the end of the year, in spite of the fact that the cable broke down completely on October 20, after conveying 732 messages. Success was not finally achieved until 1865-66, when the Great Eastern was used for the task; a course which had been proposed by *The Times* in July, 1858.

While the difficulties with the Atlantic cable were seeming almost insuperable, much successful laying of submarine cables was in progress elsewhere. Though it was only in 1851 that England was first linked with the Continent in this way, in 1858 alone cables were laid from England to the Channel Islands, from Bombay to Karachi, from the Australian mainland to Tasmania, and between India and Ceylon, as well as another in the Channel to France.

In the field of transport facilities, 1858 was not so outstanding as some previous years, but it saw the construction of the Rhymney Railway in South Wales, a number of linking lines in other parts of the country, the inauguration of railways in Ceylon, and the opening of the first portion of what was to be the Imperial Ottoman Railway, in Turkey; it extended about 70 miles, from Smyrna to Aidin. A much more ambitious project than any of these, and one still in the public eye, was that for the Channel Tunnel; for it was in January, 1858, that the Frenchman, Thomé de Gamond, proposed the construction of an iron tunnel, to be assembled on the sea bottom by an ingenious method of his devising.

During the middle of the Nineteenth Century, London experienced a considerable amount of bridge-building, and 1858 saw Chelsea Bridge completed (replaced by the present bridge in 1937) and the widening of Westminster Bridge well advanced. The strength of Westminster Bridge was put to a severe test in 1858, when the great bell for the Clock Tower of the Houses of Parliament was drawn across it on the ubiquitous flat truck belonging to Maudslay, Sons and Field; a truck which was used for many purposes at various times. The bell—the present "Big Ben," though it was not called that at first—weighs rather more than 13½ tons, or about 2 tons less than its immediate predecessor, which had been cracked by overenthusiastic "testing." The first bell, which had been already dubbed "Big Ben" after Sir Benjamin Hall, Commissioner of Works, was broken up and the metal used in casting the second; this was done on April 10 at the foundry of Mears and Stainbank, in Whitechapel-road, London. Wood fuel was used to melt the metal, because the Mears of that day considered that it produced better results than coke or coal. It was hoisted into place on October 14, by relays of eight men working a crab winch; a task which occupied about 30 hours.

The inventions and discoveries of 1858 can be only briefly touched upon, and the engineers and scientists likewise. Kelvin (then still Professor William Thomson) had devised the mirror galvanometer to detect the faint currents in the Atlantic cable. Friedrich August Kekulé (1929-96), by evolving his theory of atomic structure, laid the foundation of organic chemistry and indicated some part of the way to the developments of which the world now stands in dread. In 1858, also, Henri Giffard patented the steam injector, thus greatly extending the limit of non-stop running on railways; the Hoe rotary printing press, invented by Richard Marsh Hoe (1812-84), was introduced in London; and Jedediah Strutt patented the stocking-knitter.

There are some scientific anniversaries to note in 1758, but that year can claim, however, the founding of Kew Observatory, and John Dollond's invention of his achromatic telescope. In 1758 work began on Brindley's Bridgewater Canal (which was almost to revolutionise inland transport in England by the end of the Eighteenth Century), Bernard Forest de Bélidor (1697-1761), of *Architecture Hydraulique* fame, was appointed Director of the Paris Arsenal, and the death occurred of Pierre Bouguer whose *Traité de Navire* was published in 1746. Professor A. M. Robb has expressed the view that Bouguer "deserves, more than any other man, to be called the Father of Naval Architecture."

Finally, though a number of minor anniversaries have been passed over in reaching it, there is that of Rudolf Diesel. He was born, of German parents, at 48 Rue Notre Dame de Nazareth, Paris, on March 18, 1858, and remained in Paris until 1870, when he was sent or brought to England. Thence he went to Augsburg for schooling, to Munich University for his engineering degree, to Sulzer Brothers, Winterthur, for practical training, and then back to Paris as manager of the von Linde refrigerating firm. It was in 1893 that he published the book *Theorie und Konstruktion eines rationellen Wärmemotors*, in which he described the new type of engine that he had designed. For the next 20 years he devoted himself to its development and commercial exploitation, in face of great difficulties. He was lost overboard from the steamer in which he was travelling from Antwerp to Harwich, on the night of September 29, 1913.

Automobile Engineering

FOLDING CAR FOR AIRBORNE FORCES

By Gordon Wilkins

Harrier, Erected in One Minute, Carries Four

Technical details have now been released of the Harrier folding car for airborne forces which was demonstrated at the 1957 air display by British aircraft constructors at Farnborough. It is a four-seater which weighs less than a quarter as much as a conventional jeep-type vehicle, and takes up less than one-tenth as much space in the aircraft. Folded Harriers can be stacked on top of each other in the aircraft without racks to carry them, and can be erected by a crew of four, ready to drive, in one minute.

Despite the enormous advance in weapons of destruction, wars still call for highly mobile forces capable of completing the capture of enemy territory, and where they have to be transported by air, there is an obvious advantage in reducing the weight of their vehicles and the amount of fuel they will require.

The Harrier, created by Hunting Percival Aircraft, weighs only 700 lb. and when folded takes up only 33 cub. ft. of cargo space. Folded ready for transport by air, it measures 20 in. by 28 in. by 104 in. This contrasts strongly with the modern ¼-ton 4 by 4 vehicle carrying four to six men, weighing 3,025 lb. and taking up 370 cub. ft. of space in the aircraft. The heavier vehicle still has important jobs to do, but there is a case for something lighter and more compact. It is claimed that on a single airborne operation, the cost of the aviation fuel saved by carrying Harriers instead of conventional vehicles might nearly equal the cost of the cars, and they could herefore be regarded as expendable.

The Harrier is an open four-seater, driven by an air-cooled B.S.A. overhead-valve vertical twin engine mounted at the rear of a central chassis tube. It has a four-speed gearbox, and all four wheels are independently sprung by Armstrong coil spring-damper struts, twin units being used at the rear.

The stages in preparing the Harrier for use are simple:

(1) Lift it out of the aircraft, and take off the wooden cover over engine and rear wheels. On a military operation, the cover would be thrown away.

(2) Unclip and remove covers over front suspension.

(3) Put vehicle on the folding stands provided at each end.

(4) Swing down front wheels on their wishbones, turn the pillar carrying the suspension struts through 90 deg. and insert pins connecting struts to wishbones.

(5) Rear wheels are retracted upward and forward against the chassis tube, on pivoted base plates. Swing wheels down and outwards. Lock plates in position. Connect up suspension struts and drive shafts.

(6) Drop down sides of case to form floor, and erect folding seats.

(7) Clip on front wheel covers to form a scuttle.

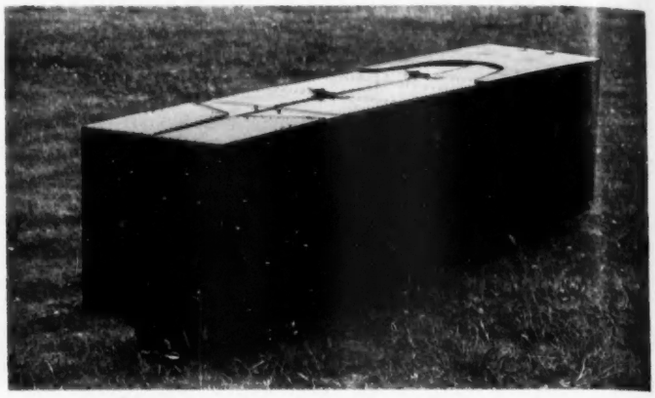
(8) Swing steering wheel into position on its swinging arm (steering gear is permanently attached).

(9) Retract stands at front and rear, and the vehicle is ready to drive away.

It will carry four men, or two men and a stretcher case, or a driver and 560 lb. of stores, mortars or machine guns.

The B.S.A. A10 650 c.c. engine is constructed as a unit with a motorcycle gearbox having four forward speeds but no reverse. A vertical chain takes the drive from the gearbox to a layshaft below, and then a horizontal chain in an oil bath in the chassis frame drives the rear axle. There is no differential. Steering is by rack and pinion, with ball-jointed links which allow front wheels to be retracted upwards without disconnecting the steering. Brakes on all four wheels are cable operated. When the side panniers drop down to form the floor, hand-and foot-brake controls are automatically engaged. The throttle pedal works via Bowden cable. There is no clutch pedal. The clutch control is incorporated in the gear lever, which returns to the central position after each gear change, like the gear control of a motor cycle. The fuel tank is carried on the vertical steering column support, and as there is not space within the folded dimensions to allow gravity feed, there is an electric fuel pump. The battery, which also works the lights, is charged by a generator with voltage regulator. Engine lubrication is by dry sump system, making use of a separate tank where the oil is filtered and de-aerated before being recirculated.

In its present state the Harrier is a prototype, and it is now being developed so that it can be dropped by parachute.



Management

THE ENGINEERING INDUSTRIES

What The Future Holds

In the series of articles of which this is the first, an assessment is made of the factors which are influencing the engineering industries at the turn of the year, and a reasoned forecast of future trends is put forward. This article deals with the fundamental factors—exports, raw materials, and wages—as they affect the industries as a whole. Succeeding articles will report on the main engineering industries.

1—EXPORTS

At this time last year in an article in ENGINEERING, the following forecast was made for 1957: "... a gradual recovery over the winter of 1956-57, a flattening out of activity over the summer, a slight decline through the second half of 1957 in the capital goods industries (that is engineering) followed by a general recession in 1958 if the Government did not try to stop it about Budget time in 1957." This forecast was made on the assumption that the Suez crisis, which was at its peak when the article was written, would not seriously affect the economic situation. In the event this proved to be the case and the forecast has been vindicated by the trend of events over 1957. Indeed, last year's prognosis provides a useful starting point for a similar exercise for 1958.

The general picture at the close of 1957 is as follows. The credit squeeze throughout the year, and its intensification in September when the Bank rate was raised from 5 to 7 per cent., has been felt particularly by the capital goods industries. Before Bank rate was increased, the deceleration in building activity had already begun, and such indicators of the state of activity in the engineering industry as the trend of machine tool orders were giving further ground for thinking that activity in engineering was losing its impetus.

Bank rate at 7 per cent., therefore, intensified a process which had already begun. The day before it was increased, the Chancellor of the Exchequer announced cuts in the capital investment programmes for the nationalised industries. Thereafter, the general state of the financial markets and the price of accommodation from the banks made it clear that a similar brake would be applied to the private sector of industry. The result was that 1957 closed with every indication of a recession in the capital goods industries, a recession which would last at least until Bank rate was reduced or the 1958 Budget brought some relief. It was apparent by November that even the iron and steel industry was going to feel the impact of recession to some extent, especially in the demand for semi-finished steel for re-rolling, and for constructional steels.

As always with these matters, however, this brief summary is an over-simplification of the situation. So far as the capital goods industries are concerned, there are some bright spots which are helping to maintain engineering activity. The two most important of these are the boom in the motor vehicle industry which, as an assembly industry, dictates the level of activity in a wide range of engineering work. The other favourable factor is the continued buoyancy of engineering exports, a subject which is dealt with more fully below. It is these two factors together with the continuing buoyancy of the consumer goods industries in general which are keeping the engineering industry out of a fairly substantial depression as 1958 begins.

While the industry may perhaps congratulate itself on having certain factors working on its behalf against severe recession, the implications of the general position are exceedingly disturbing. Official policy involves cutting down the rate of investment rather than the rate of consumption of consumer goods. This is acceptable as a short-term attack on inflation and as an emergency operation in defence of sterling, but it is the reverse of a sound long-term policy. 1958 will be a critical year for British industry. The European Common Market is almost certain to come into operation at the beginning of 1959 (in the sense that the first tariff reductions among the six Continental powers concerned are scheduled to be made in January, 1959) and the Free Trade Area tariff disarmament proposals may come into operation at the same time or shortly afterwards. It is clearly wrong, thinking in terms of the long-term factors, for British industry to preface such developments with a period of reduced capital investment.

If there is not to be a damaging cut in capital investment in 1958 there must be a reversal of official policy in the first quarter of the year. The hope of this happening depends on the continued improvement in the pound abroad, which would be reflected in a further strengthening of this country's gold and dollar reserves. To be realistic, it does not seem probable that a reversal of official policy by the spring at the latest will have the desired effect unless the two factors already mentioned as making for buoyancy continue to have a favourable influence. The possibility of the motor vehicle industry remaining resilient with so much pressure on the home market over the next few months must mean continued buoyancy in motor-car exports. Since the second factor is also the export situation it follows that the level of engineering exports this year has a critical part to play in revealing the trend of capital investment. The prospects for exports are worth closer examination.

DOLLARS OR STERLING

This country's experience with engineering exports in the first nine months of 1957 compared with the full year 1956 is set out in Table I. It gives an analysis of exports by main engineering categories to different geographical and currency areas. To judge only by the product classification, the figures are very reassuring. All the larger classifications show increases in value for the first nine months of last year compared with the full 12 months of the preceding year. The performance of machinery other than electrical is particularly encouraging.

From a geographical point of view there was a noticeable switch away from the sterling area to the dollar area last year. In the full year 1956 the dollar area took 14·5 per cent. of United Kingdom engineering exports, and 17 per cent. in the nine months of 1957 for which figures were available when this article was written. The corresponding percentages for the sterling area were 48·5 and 46·3, while the non-sterling area outside the dollar area (this means, in fact, Western Europe, the Soviet bloc and the rest of the world) remained practically unchanged at 37 per cent. This puts in simple percentage terms an export phenomenon which has been common ever since the war, namely the tendency for United Kingdom exports to the United States and Australia to move in opposite directions at any given time thus tending to cancel each other out. Last year exports to Australia were further reduced owing to import quotas, after a severe decline in 1956. In contrast, exports to the United States and Canada increased as the boom in those countries reached a peak.

This leads to the critical question about exports for 1958. Both the United States and Canada are now undergoing a mild recession, while exports to Australia are showing some signs of recovery. What are the chances that these two markets will continue to act as a counterpoise to each other? On the one hand, the United States may suffer only a mild recession. If it does, the prospects for British exports (the question of competition from Germany and other important exporters of engineering equipment is considered below) are likely to continue to be good, for Australia eased its import quotas at the beginning of December, 1957, in response to an improvement in its balance of payments position.

However, there have been serious droughts in Australia and the wool clip as well as the supply of meat for export may be adversely affected in the coming season, thereby reducing Australia's ability to pay for increased imports of capital equipment, but there is a reasonable chance that this factor may not seriously affect prospects for prosperity in Australia. If, on the other hand, the recession in the United States becomes severe, the prices of wool, meat and metals will be adversely affected and Australia could conceivably be dragged into a recession at the heels of the United States. A continued depression in America would, of course, adversely affect the United Kingdom's export markets elsewhere in the world, since an absence of industrial expansion in North America means lower prices for world commodities and hence reduced ability to pay for imports in the countries which produce them.

GERMAN THREATS

Foreign competition, especially from the United States and Germany, remains a constant threat in export markets. It has been estimated that this country's share of world engineering exports dropped from 21·8 per cent. in 1955 to 20·2 per cent. in 1956. Over the same period the United States' share went up from 35·9 to 38·4 per cent., while the German percentage crept up from 19·5 to 20·0. It is probable that the United Kingdom continued to lose ground last year, if not on a substantial scale.

TABLE I. *Exports of Products of the United Kingdom Engineering Industry to Selected Areas*
(*Monthly Averages*, £1,000)

—	1956					1957 (January to September)				
	Machinery other than electrical	Electrical machinery, apparatus and appliances	Railway vehicles	Road vehicles and aircraft	Ships and boats	Machinery other than electrical	Electrical machinery, apparatus and appliances	Railway vehicles	Road vehicles and aircraft	Ships and boats
Dollar area	4,765	2,274	227	5,246	2,373	5,566	2,716	197	6,354	3 644
Sterling area	18,916	10,159	2,739	15,526	2,492	20,545	10,636	2,533	14,968	1,627
Non-Sterling area ..	18,284	5,673	809	10,269	2 931	20,146	5,782	862	10,963	2,054
Of which to O.E.E.C. countries and dependencies	11,568	3,249	269	6,619	2,171	13,444	3,398	222	7,135	1,204
Soviet Bloc	799	282	—	37	—	996	289	—	33	272
Rest of World (residual)	5,917	2,142	541	3,613	760	5,706	2,095	640	3,795	578
Total exports	41,965	18,106	3,775	31,041	7,796	46,257	19,134	3,592	32,285	7,325

Continuing Management

The large share of world engineering exports held by the United States tends to fluctuate, although it remains considerably higher than that of the United Kingdom or Germany. Broadly, however, United States engineering exports tend to be high when activity in the United States home market falls off. This means that there will possibly be increased competition from the United States in 1958.

So far as Germany is concerned, its share of world engineering trade has been growing ever since the stabilisation of the Deutschmark in 1948. It may well be true, and it is certainly hoped for in this country, that the recent increase in raw material prices and continuing pressure for higher wage rates in Germany will reduce German price competition, but this is only part of the problem. Much of the German strength is based on its traditional hold on some markets (especially in Europe), hard selling and good servicing.

There is another complication to face in 1958. The European Common Market will almost certainly be established and the first tariff reductions come into operation at the beginning of 1959. Germany, therefore, is on the verge of operating in a very much enlarged domestic market—whatever may happen to the Free Trade Area. Even if there is some shift in the arms burden from Britain to Germany this year, and even if inflationary pressure in Germany raises costs and prices, the working assumption must be that this country will have to sell harder in order to maintain its present percentage of world engineering trade. There is every incentive to do so, for this country's exports are becoming increasingly dependent on engineering. In 1956 engineering exports amounted to 38·9 per cent. of total United Kingdom exports and in the first nine months of 1957 the percentage had gone up to 39·4.

While it is true that maintaining and even improving upon the present rate of export is not entirely a matter of price, prices remain an important consideration. The ability to export must therefore depend on the trend of costs and prices in the industry as a whole or, rather, upon the relation of costs to prices. This relationship is at the moment fairly complex. Export prices of engineering goods rose according to the official index from 109 in January, 1957 (taking 1954 as 100) to 114 in September, an advance of 5 points. This was the same increase as in the 12 months of 1956 and slightly more than in 1955. In the case of metal goods the rise last year was somewhat less.

The main conclusion, however, is that export prices were rising as quickly last year as in 1956. The third quarter's analysis of company profits by the *Economist* covering 126 engineering concerns (including shipbuilding, electrical manufacturing, motors and aircraft) showed an increase from £70·7 million to £72·5 million or 3 per cent., compared with the same companies in the same quarter a year before. This analysis covers only public companies and can be taken only as a rough guide to the experience of the engineering industry as a whole, but the figures suggest that the pressure on gross profit margins in the quarter closing with the increase in Bank rate was not drastic in a great many cases. Since these figures are struck before depreciation, which should take an increasing allocation of profits at a time of rapid technical change and inflation, it would be unwise to read more than the above broad conclusion from them. Since engineering exports account for a substantial percentage of total engineering output the rise in export prices has played a useful part in maintaining profit margins.

2—RAW MATERIALS

On the cost side, raw material prices and wages have been pulling in opposite directions and may continue to do so. According to the Board of Trade index of wholesale prices of materials used in mechanical engineering, there was an increase of 2 per cent. between January and September last year, but in materials for electrical machinery the index dropped by 4 per cent. Since raw material prices, notably the base metals, were falling in the last quarter of the year it is almost certain that the price of raw materials for electrical engineering products fell even further, and that the upward trend in the price of materials for mechanical engineering equipment was halted.

Is this trend of raw material prices likely to continue into 1958? Throughout 1957 industry was laying-in increasing stocks, especially of iron and steel raw materials and semi-finished products and, indeed, industrial stocks as a whole were about 4 per cent. higher at the end of September than they were at the end of March (measured by value) so that in the autumn British industry on the whole was fairly comfortably stocked with raw materials at less than peak-1956 prices. It is not likely, therefore, that a recovery in base metal prices in the early months of 1958 would be helped by a rush to buy. The prospects for raw materials can, however, be assessed only after examining the prospects for each main commodity individually.

STABLE STEEL

Steel prices were increased in July, 1957, and by September they were running on the average at about 8 per cent. above the level in January last year. Towards the close of 1957 there were distinct signs that the steel industry was running in some sections below capacity, notably in constructional and alloy steels, but the market was taking as much plate and sheet steel as could be produced. In an ordinary commercial market this might be assumed to indicate a fairly long period of stable steel prices and even a few modest reductions, but this cannot be assumed so readily for the steelmakers. Prices of steel in the United Kingdom market are fixed by the Iron and Steel Board, which takes into account the cost of steel and the need for a margin to enable the industry to replace its assets. Since United Kingdom steel prices are still a little below Continental prices, there is no pressure from abroad to lower prices. In such circumstances it is not likely that a modest reduction in deliveries from the steelmakers will reduce prices. Indeed, if steel costs continue to rise, prices are likely to go up as well. Nevertheless, on balance there is a prospect of fairly stable steel prices for 1958.

Throughout last year aluminium prices remained stable and there is little likelihood of an increase in 1958. There is, in fact, some prospect of a decline in prices, for the industry has allowed its capacity, especially in the United States, to expand in excess of demand. Meanwhile, the Russians have been selling aluminium ingot at prices about 10 per cent. below those in Canada and Western Europe. There have recently been opinions expressed by aluminium users that a 10 to 20 per cent. cut in aluminium prices here would stimulate sales. Another factor is the severe drop in copper prices mentioned below. In the last five years aluminium has made notable strides into traditional copper markets on its price advantage. With the price of copper more than halved in eighteen months, the scope for substituting aluminium for copper has been severely reduced. It would not therefore be surprising if aluminium prices fell in 1958.

Copper prices fell severely in 1957 and there is no prospect of an equally dramatic recovery in 1958. During last year the dual pricing system for Rhodesian copper came to an end, and in this country the London Metal Exchange now makes the only price on which contracts are based. As has happened so often in the past, a rapid decline in the price of a commodity has made it impossible for a producer to try to stabilise prices. In this case it was Rhodesian Selection Trust Limited, with its fixed price policy. At the middle of December, 1956, the cash price for copper was £272 per ton. Exactly a year later it was 32 per cent. lower at £182 per ton. Although high-cost producers cannot operate profitably at this level (in October, 1957, the chairman of Anaconda said that prices had come to a level where it was impossible for much of the mining industry in the United States and Chile to operate profitably) nevertheless it has not been possible to persuade producers to accept an agreed 10 per cent. cut in output. Opinion is divided as to whether the low level reached in the autumn of 1957 represents the bottom of the market, but there is general agreement that recovery, when it comes, is likely to be gradual. World stocks of copper by November were fairly high at about 920,000 tons and it is generally agreed that it will take a recovery in the level of United States consumption to reduce these stocks to a much more conventional level.

The general feeling is that copper prices may recover fairly rapidly to a price of around £210 per ton, but that any increase above that level will be slow, and it is unlikely that the fantastic levels of March, 1956, when copper reached £436 per ton, will recur. In the long run the outlook for copper is still good and it is thought that by 1960 demand may again be ahead of supply. This is likely to lead to a gradual increase in the price but not to major price advances such as occurred in 1954 and 1955.

LEAD, ZINC AND THE U.S.A.

Lead and zinc prices have recently been depressed by developments in this country and in America. In this country the Board of Trade is engaged in selling its remaining stock of 20,000 tons of lead and 27,000 tons of zinc. In the United States, the Administration has been asked to impose a sliding scale of tariffs on imported lead and zinc. This policy is in sharp contrast to the one pursued until recently by the United States Government. Since the middle of 1954, it has been stock-piling surplus foreign lead and zinc in barter deals involving the sale of American farm produce. Although the main object of this was to support farm prices in the United States, it has also bolstered lead and zinc production throughout the world. It seems likely that the proposed tariffs will be enacted and this will have a depressing effect on world production especially as the demand for the base metals in America is in any case easier owing to the industrial recession.

In mid-December lead prices at £72 a ton in this country were 36 per cent. lower than at the same time a year ago, and zinc prices at £62 a ton were 37 per cent. off. There is not likely to be a significant increase in zinc and lead prices for some time and, although the long-term outlook is good since the prospects for the battery and cable industries are good, the industry has to adjust its rate of production to the decision of the United States Administration to stop stock-piling these metals.

The International Tin Council brought a new agreement into force in 1956 to prevent excessive fluctuations in tin prices. The floor and ceiling prices fixed were £730 and £880 a ton. Towards the end of last year the price was at floor level and the industry was running a surplus in the closing months of the year. The creation of a buffer stock has been written into the agreement to iron out short-term fluctuations of prices by operating at the floor and ceiling levels and by making provision for export quotas. In spite of the very adequate resources of the buffer pool to carry any foreseeable stock for a fair length of time, the market has been exceedingly nervous in recent weeks and producers have shown great alacrity in unloading tin at just above £730 a ton. About 40 per cent. of world supplies of tin go to the tinplate industry which is gradually evolving more economic ways of coating steel.

The prospect for tin is therefore problematical even at £730 a ton. To the effect of technological changes must be added the effects of

the current business setback in America which creates temporary loss of confidence in the metal's future. Altogether, there is every prospect that tin prices will be at recent comparatively low levels for some time, although the fixing of export quotas has been a steadying influence at the close of the year. If there were a sudden shortage of tin, however, consumers would feel its impact very quickly, for tin cannot be released from the buffer pool until the price is £830 per ton, or £781 when export quotas are in operation.

NICKEL AND PLASTICS BRIGHT

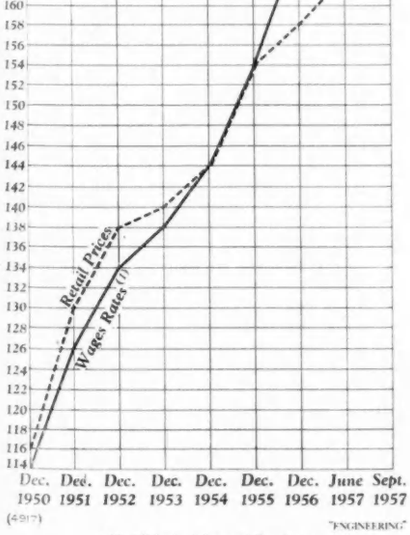
Among the light metals titanium has had a bad year with the contraction of the aircraft industry. One of the United Kingdom manufacturers closed down a pilot plant in December which, in its way, typified the general setback to the commercial development of titanium for the time being. Nickel is still fairly scarce although the shortage is less acute than in the recent past. The United States Government will not be buying nickel for stock piling in 1958 and this will go some way towards further easing the market position. The general opinion is that the early 1960's will see the end of the shortage. By then new supplies will be available from the International Nickel Company of Canada from its Manitoba and Ontario developments and also from Cuba. A high proportion of nickel goes into stainless steel and high-temperature resisting alloys. Since the outlook for both these kinds of steel alloys is good, the long-term outlook for nickel is fairly bright. It would not be surprising if the nickel position became easier before 1960. Stocks in the hands of United States users last September were the highest in history. The general outlook is for better supplies and stable prices. In the last few years nickel has come down from between 3 dols. and 4 dols. per lb. to 1 dol. a lb. and there seem reasonable prospects of prices settling down at this lower level.

The plastics industry is in process of trying to reach an output target of 500,000 tons a year by about 1960. In 1957 the rate of expansion was about 16 per cent., giving an output of 400,000 tons. There seems every indication therefore that the overall target will be reached about on time. Most of the expansion has been in thermoplastic materials. Polythene sales went up by 40 per cent. last year, and the market for P.V.C. has also sharply expanded. Exports were buoyant in 1957 and there was an outstanding technical development of importance, namely, the bonding of plastics on to steel, a new process which is being commercially exploited by John Summers and Sons, Limited.

To sum up on the effect of raw material prices on engineering costs this year, it seems unlikely that prices will increase significantly beyond the levels obtaining in December, 1957. The likely pattern seems to be a further easing of prices on the whole through the winter months, followed by a gradual recovery in the summer. Individual materials may behave differently, of course, from the overall pattern but the only factor which could seriously change the latter this year would be either a sudden political crisis leading to international tension on the scale which was apparent in the winter of 1956/57, or a very rapid recovery in United States industrial activity this spring.

3—WAGES AND WORKING HOURS

The other source of pressure on costs is wages. Here the position is much more difficult to foresee than the effect of changing raw material prices. The wages situation is exceedingly critical. This winter there is not likely to be much attempt made by organised labour to hide its demands for higher wages behind rough-and-ready calculations about the level of profits, productivity or the cost of living. Everyone knows that the issue this time is likely to be a straight trial of strength on the issue of an annual wage increase.



(1) All Industries and Services.

Relative movements in retail price and wage rates since 1950. Index: June, 1947 = 100.

The statistics, in so far as they affect the situation at all, are not easy to interpret. The relative movement of wages and retail prices is plotted in the graph on the left. Between January and September, 1957, the official index of retail prices went up by 3 per cent. whereas wage rates in manufacturing industry went up by just over 4 per cent. Wage rates therefore more than kept up with the cost of living.

On the other hand there has been an increase in short-time working and a decrease in overtime which has prevented the level of earnings increasing as rapidly as in past years. In addition, unemployment in November reached 1·5 per cent. of the employed population compared with 1·3 per cent. in October and 1·2 per cent. a year before. Within the overall picture, of course, there are important differences as between industries, but even in engineering (including vehicles) there were slightly fewer persons employed at the end of October in 1957 than there were at the same date in 1956. The big changes compared with last year were the flow to the distributive trades and the continuing decline in the textile industries, notably cotton. The employment pattern was in fact following the trade cycle, as can be seen from Table II.

Consumer goods as a whole have been doing well and attracting labour, while the capital equipment industries have suffered to some extent from a slowing down in their rate of increase of output.

GOVERNMENTAL STAND

So far as the engineering industry is concerned, a year's moratorium on wage increases will expire in the spring, but the climate for any wage negotiations will probably have been set beforehand. To some extent the trend of wages in engineering in 1958 will be established by the outcome of the A.E.U.'s demand for a 40-hour week which the employers have already formally turned down. As this article is written the refusal by the employers is the final word. The deliberations by the union as to what should be their next move will probably be overtaken by the wage situation in general.

The London bus drivers and the railway employees both have wage demands in for consideration. The first of these has already been turned down and the second is likely to meet with the same reception. The Government has said that it will not finance further deficits by the nationalised industries which arise out of the demand of a larger wage bill, and this is bound to mean a hardening of opinion against further wage increases in those nationalised industries which are operating at a loss.

The Government has also drawn the attention of wages arbitration tribunals to the importance of arbitrating against the background of current opinion on economic affairs—which is a broad hint that arbitrators must take the tough line. In addition, the Treasury has been instructed to take a firm line with salary increases in the Civil Service by insisting that any increases due to salaries shall be offset by corresponding economies elsewhere in the department. The Government has therefore staked its reputation, indeed its survival, on holding wage levels and hoping that the favourable trend in raw material prices will help to bring down the cost of living.

The unions, to judge from events in December, are approaching the situation with circumspection. Some of them, such as the Transport and General Workers' Union and the engineering unions, suffered some depletion in funds last year with the strikes in the spring and they may be unwilling to stand a further severe reduction in their reserves. The T. and G.W.U. are also aware that their faces were saved last year in the

TABLE II. *Employment in the Metal Manufacturing and Engineering Industries of Great Britain (Thousands)*

—	End-Sept., 1956	End-Sept., 1957
Metal Manufacture	580·7	583·3
Blast furnaces	22·6	23·4
Iron and steel melting, rolling, etc.	229·4	235·9
Iron foundries	123·2	119·3
Tinplate manufacture	15·4	11·3
Steel sheet manufacture	21·5	22·3
Iron and steel tubes (incl. melting and rolling in integrated works)	51·5	52·5
Non-ferrous metals, smelting, rolling, etc.	117·0	118·6
Engineering, Shipbuilding and Electrical Goods	2,109·8	2,120·8
Shipbuilding and ship repairing	214·2	214·8
Marine engineering	79·7	78·8
Agricultural machinery (excl. tractors)	39·9	39·7
Boilers and boiler-house plant	32·2	33·4
Machine tools	119·3	118·8
Stationary engines	29·7	28·3
Textile machinery and accessories	62·1	58·3
Ordnance and small arms	63·6	57·6
Constructional engineering	87·6	86·2
Other non-electrical engineering	686·1	688·8
Electrical machinery	198·2	201·2
Electric wires and cables	65·0	65·1
Telegraph and telephone apparatus	60·3	61·9
Wireless apparatus (excl. valves) and gramophones	132·1	142·2
Wireless valves and electric lamps	48·5	50·6
Batteries and accumulators	19·6	17·7
Other electrical goods	171·7	177·4
Vehicles	1,193·2	1,184·2
Manufacture of motor vehicles and bicycles	305·7	305·0
Motor repairers and garages	292·3	277·4
Manufacture and repair of aircraft	263·5	261·3
Manufacture of parts and accessories for motor vehicles and aircraft	164·3	170·7
Locomotive manufacture	75·6	76·5
Manufacture and repair of railway carriages and wagons and trams	84·1	85·6
Carts, perambulators, etc.	7·7	7·7
Metal Goods not elsewhere specified	513·4	499·9
Tools and cutlery	43·2	41·0
Bolts, nuts, screws, rivets, nails, etc.	43·9	43·1
Iron and steel forgings, not elsewhere specified	40·9	42·1
Wire and wire manufacture	40·9	40·1
Hollow-ware	59·3	56·8
Brass manufacture	49·0	46·9
Metal industries not elsewhere specified	236·2	229·9
Precision Instruments, Jewellery, etc.	146·4	146·7
Scientific, surgical and photographic instruments, etc.	90·6	91·3
Manufacture and repair of watches and clocks	16·9	16·7
Jewellery, plate and refining of precious metals	29·7	29·6
Musical instruments	9·2	9·1

Source: Ministry of Labour Gazette, October, 1957.

Continuing Management

strike of provincial bus workers only by the decision of the arbitrators, who suggested a compromise just as it was becoming apparent that the strike was seriously antagonising public opinion among the working classes. This was a salutary lesson, and union leaders are not rushing to burn their boats on the wages issue as the new year begins. Some of the more militant unions, the boilermakers is one example, have threatened to indulge in various forms of non-co-operation if they do not get what they want, but a bigger danger to industrial peace is probably militancy among the rank and file of some of the big unions, notably the T. and G.W.U. London bus operatives have a tradition of militancy which may lead to strike action, although the demand which they put forward to the London Transport Executive at the end of November was little to the liking of their senior officials.

There is a formidable list of wage claims or modifications to working hours already before employers. In addition to the railway men, engineering operatives and shipbuilding workers, the building unions and the miners have demands in for a 40-hour week and there are a large number of demands going forward in the consumer goods industries as well. The credit squeeze, which has been intensified since September, will tend to line up employers on the same side as the nationalised industries because funds to carry larger turnover or higher costs—no matter what profits may be doing—will be difficult to come by. There is every prospect, therefore, of a trial of strength, and it is exceedingly difficult to forecast what the outcome will be. Since the autumn began, only the Co-operative societies have given wage increases, and even these can be regarded to some extent as a belated effort by the co-operatives to bring their wages and salaries into line with the market price.

SWORD OF CLAIMS

The prospect for 1958 for the engineering industry can be summed up as follows. In many key sections of the industry, such as building contracting and machine tools, order books are running down, and if present forces are left by the Government to operate freely a recession of some size could develop. How far it would develop depends on the level of exports, which is closely connected with the state of business confidence in the United States, Australia and Western Europe. The worst combination of circumstances for the engineering industry would be a continuation of the credit squeeze and further trade depression in the United States. The best combination would be an upturn of American business in the spring and a relaxation of credit restrictions. So far, the prospect is fairly straightforward. Over it all, however, hangs the problem of wage claims this winter.

If Government and industry give way to organised labour there will probably be another sterling crisis not later than next autumn. If they do not give way there is likely to be some industrial unrest, an increase in strikes and a loss of output. However painful this may be from a domestic point of view, it will increase foreign confidence in the strength of the British economy. Since, on balance, the prospect is for a firm line on wage claims, the engineering industry may experience falling output due to industrial dislocation. Thus, one way or the other, except in certain fortunately placed sections of the industry such as shipbuilding and motor vehicles, there is likely to be a fall in turnover from one cause or another and this is likely to be accompanied by reduced raw material costs. In consequence, profits may not fall as severely as might be expected—provided the dislocation, whether it comes from labour or from demand, is sharp but short. If this happens the autumn and winter of 1958 may see a significant recovery.

Metals and Materials

BURSTLEIN COAL-PREPARATION PROCESS FOR COKING

An exclusive licence to build plants in Great Britain in accordance with the Burstlein process of coal preparation for coking has been granted to the Woodall-Duckham Construction Company Limited, Woodall-Duckham House, 63-77 Brompton-road, London, S.W.3. The process, which is dependent upon selective and petrographic treatment, has been developed by Mr. Eugène Burstlein, of the Société Lorraine Escaut, and has been in regular use for the past six years at the firm's coking plant at Thionville, Moselle, France.

Mr. Burstlein's technique takes account of the fact that the different coals which go to make up a coking blend, and also the petrographic constituents of each of the individual coals, vary widely in coking power, in hardness and in grain size. By various combinations of screens and disintegrators, the process ensures that all the constituents of a blend have the optimum sizing for the production of a strong coke. In conventional coking practice, the indiscriminate action of the hammer mill tends to make friable coals and the soft petrographic constituents too fine, while leaving the harder particles, such as durain and shale, too coarse.

It is emphasised that during the past six years, numerous full-scale tests have shown the effectiveness of selective and petrographic preparation in improving coke quality and reducing the production of breeze. The process is capable of being applied to any existing coking plant, the special screening and size-reduction equipment replacing the normal hammer-mill. An important development of the new process is a high-capacity electrically-heated screen, which is capable of handling wet slacks without clogging.

Apart from the original installation at Thionville, there are now eight further Burstlein units either operating or under construction in carbonising plants in France, Western Germany, Italy and North Africa. These range in capacity from 7 to 250 tons an hour and vary in complexity according to the type of coal to be treated. In Great Britain it is pointed out that the process may be used to obtain an improved coke from a given blend of coals, or to enable cheaper or more readily available coals to be utilised without sacrificing coke quality.

SODIUM HYPOCHLORITE FOR STERILISING WATER

The sterilisation of large quantities of power station condenser and other waters for the prevention of algal or mussel growths may be accomplished by means of sodium hypochlorite produced by continuous flow electrolysis. Although sodium hypochlorite may be prepared in several ways, the simplest method is to pass an electric current through a solution of common salt. This splits up the solution into its constituents, with the production of chlorine, oxygen, sodium hydroxide, etc., thus providing an active solution which is ideal for sterilising water if applied when quite fresh.

The Paterson Engineering Company Limited, Windsor House, Kingsway, London, W.C.2, have now placed on the market a new range of their Clorocel equipment, termed the CF/E series electrolysers, which are primarily intended for use with water flows in excess of 30,000 gallons an hour. The Clorocel equipment, using a weak brine, varying from 5 to 15 per cent. sodium chloride content, converts the sodium chloride into electrolytic sodium hypochlorite (often abbreviated to E.S.H.) of the appropriate strength as and when required. Where sea water is available this provides an economical method of producing the sodium hypochlorite.

The CF/E type of Clorocel unit consists of a steel tank, covered and lined with insulating material, at the bottom of which lies the electrolyser. This is composed of a number of disc-shaped electrodes arranged coaxially and fitted into an insulating case built up in sections and secured by tie rods. The unit is surrounded by a cooling coil, through which water is passed when necessary to maintain the electrolyte at the best working temperature. A rectifier unit for the production of direct current is also supplied. The strength of the sterilising medium obtained is governed by the electric current applied and may also be varied by controlling the flow of salt solution from the salt saturator or other source of brine. By introducing suitable regulators and switchgear the production of hypochlorite may be automatically governed by the demand.

The CF/E electrolysers are supplied in sizes capable of dealing with water flows of from 50,000 gallons an hour, with an electrical consumption of from 2 to 3 kWh, up to as much as 1 million gallons an hour, consuming from 38 to 57 kWh.

FIRE IN A COLLIERY: AMERICANS TEST BRITISH METHOD

A new method of fighting colliery fires which originated in this country at the Safety in Mines Research Establishment, is to be tested under mining conditions in the United States. The "foam-plug" technique, as it is called, involves the use of foam-producing substances similar to those employed in household and commercial detergents and in foam-bath preparations.

In describing the process recently to an audience of mining engineers in Kentucky, Dr. Irving Hartmann, chief of the United States Bureau of Mines Dust-Explosions Branch, Pittsburgh, Pennsylvania, stated that the foam is generated by spraying a bubble-making solution on to a cotton screen or net stretched across a colliery road. As the solution penetrates the net, large bubbles form and quickly fill the entire cross-section of the tunnel. The mass of foam is carried by the mine ventilating current to the fire zone, where the water in the foam vaporises, reducing the oxygen content of the air and subduing the flames.

When a fire starts in a colliery, it frequently happens that fire fighters are unable to approach near enough to combat it and, in the opinion of Dr. Hartmann, if the foam-plug technique can overcome this obstacle, it will constitute a significant advance in mine safety.

Tests to determine whether the new method can be adapted to American mining conditions are scheduled to commence shortly at the Bureau's experimental coal mine near Bruceton, Pennsylvania, and portions of the mine are being modified for carrying out the investigation. The results of the tests will be awaited with interest on this side of the Atlantic.

COATING MATERIAL FOR CHIMNEY STACKS

A new high-temperature coating material specially designed for the protection from rust of steel chimney stacks, furnace doors and other steelwork subjected to high operational temperatures, has been introduced by Corrosion Limited, 16 Gloucester-place, London, W.1.

The material, to which the name Glostack has been given, is a metal coating supplied in liquid form. It is applied by normal paint techniques and is stated to be simple to use as it does not need the addition of a hardener, accelerator or curing agent. The surface to be coated is prepared in the usual manner and the new material is brushed on cold. The article may be put back into service as soon as the coating is finger dry, which takes about two hours.

Experience during the development of the new coating has shown that it will withstand temperatures up to well over 800 deg. F. (430 deg. C.), for long periods. It is emphasised that, in addition, the coating has the important property of being stable and unharmed by a wide range of temperatures from the normal atmosphere to its upper limit of usage. Among other properties given for the new material are particularly good resistance to weathering conditions and to attack by chemical fumes.

Glostack is sold by weight and is supplied in 6 and 12 lb. cans.

★ ★ ★

ASBESTOS FRICTION MATERIAL

Specially developed for certain industrial and mining applications, a new woven asbestos friction material has been placed on the market by Ferodo Limited, Chapel-en-le-Frith, Stockport, Cheshire. The new material, Ferodo ZA.1, is intended for use with winding and haulage gear, where high temperatures and arduous working conditions are encountered, and comparatively soft brake pads are in use.

The material has a zinc wire inclusion and extensive field tests have shown it to have a stable coefficient of friction of from 0·38 to 0·4. It is suitable for use where temperatures of up to 300 deg. C. (572 deg. F.) are encountered and it is pointed out that it has a relatively high degree of flexibility. This not only helps to eliminate "squealing," in plants prone to this complaint, but also allows the material to be easily formed to a particular radius on the site without the need for special tools.

Ferodo ZA.1 is available in roll form up to 20 in. wide and in thicknesses ranging from $\frac{1}{8}$ in. to 1 in.

★ ★ ★

DENSIFIED WOOD: FILM

The applications of Hydulignum—resin-impregnated densified plywood—are illustrated in a black-and-white sound film prepared for the makers, Hordern Richmond Limited, Haddenham, Buckinghamshire (a member firm of the Permali Group), by the Big Six Film Unit, Hydulignum was developed during the second World War specifically as a blade material for variable-pitch propellers, with the properties of stability, high strength and hardness combined with the machineability of wood, and a density about half that of aluminium.

As shown in the film, "The Hydulignum Story," the material is widely used, particularly in the aircraft industry and also in the manufacture of Kelvinator refrigerators, motorcycles and car radiators, etc., for such things as router jigs, Hydropress and rubber press tools, and stretcher-press formers. A subsidiary of Horden Richmond Limited, Hydulignum Jabroc Tools Limited, offers advisory and manufacturing services in jigs, tools and fixtures.

Marketing

THE CANADIANS RETURN

Dollar Exports Council to Appoint Group Leaders

On Tuesday, December 17, the Canadian Trade Mission left this country after a most useful if somewhat breathless stay of 3½ weeks. Before they left they met the Press again, as they did on their arrival, but this time on a common platform with the Dollar Exports Council and its sponsoring organisations, the Board of Trade and the Federation of British Industries. Sir David Eccles, president of the Board, was there; so was Sir Norman Kipping, director of the F.B.I., Sir William Rootes, chairman of the Council, and of course the leaders of the Mission, Mr. Gordon Churchill, Minister of Trade and Commerce, and Mr. J. S. Duncan, chairman of the Dollar-Sterling Trade Council. Their statements are discussed in subsequent paragraphs. It has also been announced that a permanent organisation to foster good trade relations between Canada and the United Kingdom is to be set up in Ottawa. In charge will be Mr. Peter Stursberg who has been in charge of publicity while the Mission has been here.

ENGINEERING has attached a great deal of importance to this manifestation of goodwill on the part of the Canadians. We believe, like Mr. Gordon Churchill, that goodwill, and the sentiment upon which it is based, definitely has a place in business. Everywhere there is evidence that by and large people prefer to trade with those they like and trust. Mr. Churchill is right enough when he says that "those who fail to recognise the explosive power of sentiment in business are overlooking one of its strongest weapons."

The Canadians leave Britain with a new awareness of her achievements in many technical fields, the importance of her research effort and the might of her manufacturing industry. On leaving they make suggestions for prompt action on our part and promise action on their own account. They also proffer advice to exporters which may be elementary but which has too often been ignored, even by large firms, within the past decade. A little extra zeal will not be amiss, and perhaps we can draw inspiration from the following words of Sir William Rootes: "These 57 crusaders have barnstormed this country. There has never been a Trade Mission quite like it. We know they have had little rest. They have visited factories and interviewed over 1,000 British industrialists. They have created an atmosphere that has jolted many of us into realising even more strongly that Canada is a tremendous and growing market."

Action by Governments

The statements of Mr. Gordon Churchill and Sir David Eccles on the further action to be taken in order to achieve the Canadian objective of a switch of her imports from the United States to this country (amounting to 15 per cent. of current imports from the United States and worth over £250 million) suggest that a considerable effort will be made by the Governments concerned, or by semi-official organisations such as the Dollar Exports Council and its Canadian opposite number, the Dollar-Sterling Trade Council.

Mr. Churchill announced a decision to make "a closer analysis" of all Government purchasing—national, provincial and municipal, including Crown companies, in an endeavour "to replace many of our present imports by United Kingdom sources." The D.S.T.C. membership will be raised, its income increased and the campaign this organisation has carried on since 1949 to encourage Canadians to buy more of their requirements from Britain and less from the United States will be stepped up considerably. Canadian purchasers will be encouraged to order further ahead to give British suppliers a better chance to meet delivery requirements.

Sir David Eccles announced that all British Trade Commissioners in Canada will be called together next month to meet members of the mission and hear their report, giving guidance on how to improve their service to British exporters. The Board of Trade will play a part in the small but strong return mission which the Dollar Exports Council are sending to Canada in the spring. Sir David is discussing with the British Travel and Holidays Association arrangements for encouraging more Canadian tourists to come over. Both he and Mr. Churchill announced their strong support of measures to be taken by the D.E.C. "to encourage more Canadian students and apprentices to come to this country for technical training." Sir David Eccles' closing words were "when we have fully digested the results of the Mission we may well find that it has started something of great significance for Commonwealth trade." And, as one Canadian said, "the whole thing could easily come off."

Co-operative Exporters—A New Idea

More than 1,000 British manufacturers came to meet the Canadian mission. A clearer demonstration of keen interest could not have been shown. The Dollar Exports Council are greatly encouraged and have proposed action to sustain this interest and to make possible an active follow up in Canada by a large proportion of these firms.

The most important decision of all affects the medium and small firms. The Mission pointed out the importance of the smaller producers to the British economy, most of whom are "both unaware of the opportunities in Canada or the methods of procedure to compete satisfactorily in our market." In Mr. Churchill's view, "it is largely to them that continuing attention must be given." Whether or not one shares the view that the small firm should be encouraged, it is a fact that they take up a considerable proportion of the nation's resources and that they export far too little to pay for the imported materials which they use.

The D.E.C. state the problem quite simply: small exporters cannot afford an adequate selling effort or the maintenance of a competitive spares service. They have to rely too much on their agents. They say "there has been much talk and exhortation in the past about this problem, but little has resulted. Now we intend to take positive action to form groups of suitable companies selling different products to the same customers." This is a very bold step, and probably the only measure which could have any chance of success.

They will identify men who are successful but relatively small exporters to Canada and ask them to accept appointments as leaders of groups to be formed around them. The D.E.C. comment that "there will be no difficulty in preparing lists of exporters likely to benefit from membership of such groups, once the experienced leadership has been established." With the support of the F.B.I., and presumably also of the National Union of Manufacturers, the D.E.C. will discuss arrangements with some of the larger United Kingdom exporters to Canada who have sales and warehouse facilities already established there, "with a view to their accepting agencies for some of our smaller exporters." The help and support of the principal trade associations will be requested and the proved facilities of Trade Commissioners'

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offices will obviously be available. The Council have a splendid opportunity to start off a movement which would materially affect the export performance of the whole country, not only in Canada but in other markets.

Advice from Canadians

The members of the Mission took every opportunity to hammer in the main do's and don'ts which make for success in exporting to their country. Mr. Churchill expressed the Mission's confidence that "providing suitable measures are taken, much of the lost ground can be re-gained." The main basis for this confident expectation is simply that British products have "two outstanding advantages in our market: the price is competitive with that of American imports, and the quality is generally recognised as being first class."

Mr. Churchill did not think the decision to enter the Canadian market should be taken lightly: it is necessary to consider three to five years as a "fair trial" and to be prepared "to make the sacrifices which are frequently present in a new venture." A thorough investigation of the market must first be made, and the disadvantages of the United Kingdom exporter *vis-à-vis* his United States competitor clearly recognised. The influence of the styling, packaging and engineering design of the American producer; the fact that so many Canadian companies are American controlled and utilise their parent companies' specifications, engineering standards and general business practice; the considerable differences which exist between United Kingdom and Canadian tastes, habits, preferences and requirements due to geographical location, different climate, higher cost of labour and the influence of Canada's proximity to the United States—all these are very real obstacles to overcome. They can only be overcome, said Mr. Churchill, by adaptation to the prevailing standards and requirements. The more quickly the United Kingdom manufacturer can conform his production to these standards, "the more rapidly he will be able to obtain a place in the Canadian market and, in view of his price structure, frequently in the United States market also."

A great deal of the advice related to consumer goods but much was universally valid. Service is of the utmost importance—not only that it should be good but inspire confidence from the start that it will be good. Too many firms have pulled out of the Canadian market leaving machines and equipment they had sold without any arrangements for servicing and, even more important, for the prompt despatch of spares. On the question of delivery, all members had much to say. There is no point in a manufacturer seeking to establish a foothold unless he is prepared to quote delivery dates competitive with local or U.S. manufactures.

Apart from the factors already mentioned, there is the need to advertise, which is greater than in most other markets. In this respect Mr. Churchill advocated "a co-operative appeal among all United Kingdom exporters" to stage major advertising campaigns in favour of buying British goods, stressing the interest which both countries have, on economic grounds, in expanding trade with one another. The Mission have left to begin a new task, that of putting to their countrymen the case for considering Britain as a source of imports. They will help to prime the pump, particularly—to quote the D.E.C. report—to overcome "the sheer momentum of established trade connections," to make sure British firms are asked to tender for products now going "almost automatically" to previous suppliers. They will help to make it possible for Canadian testing and certification procedures, in such fields as pressure vessels and gas appliances, to be carried through within the United Kingdom. To get anywhere they will need the whole-hearted co-operation not only of the D.E.C., but of the whole of British industry.

Research and Development

RAM-JETS

*By R. P. Probert**

We give below extracts from a lecture given recently before the Royal Aeronautical Society in London, on "Ram-Jets."

The ram-jet consists of an intake or diffuser which converts to pressure some of the kinetic energy due to relative motion in flight, and supplies the air inspired to a high-pressure combustion chamber, which in turn discharges hot gas rearwards through a propelling nozzle. Pressure ratio naturally increases with flight speed, and overall efficiency, or thrust work per unit of fuel, can increase indefinitely with speed towards 100 per cent. Practical limits set by excessive ram temperature do not arise until a Mach number of 4 is exceeded.

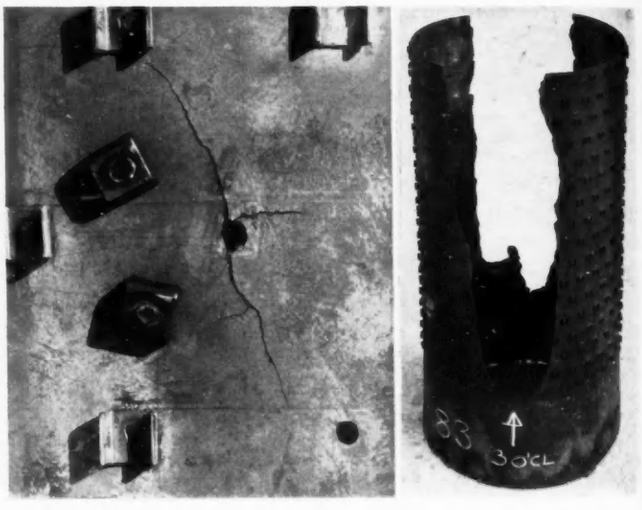

Fig. 1 Catastrophic failure of a combustion chamber. The initial crack, seen in the left-hand picture, spread in a few seconds to total destruction as shown on the right.

Only the guided weapon has yet given the ram-jet a real job to do. The weapon, whatever its sustainer motor, is launched ballistically to supersonic speed by jettisonable rockets, partly to lighten, cheapen and simplify the weapon itself and partly to reduce time to interception. Here, thrust deficiency at low speeds is immaterial and good economy, light weight and relative simplicity in the supersonic speed band make the ram-jet an attractive motor for the longer ranges.

It is possible to design a ram-jet engine which, simultaneously climbing and accelerating, provides roughly constant thrust over a large change of height. This latent acceleration and climb capability is a very handsome start to supersonic flight. If, now, at high speed the nozzle is closed and the temperature reduced (accompanied by closure of the intake) one can drop down to a quarter of maximum thrust with a drop of some 40 per cent. in specific fuel consumption. Clearly an engine with fully variable intake capture and throat areas and variable exhaust throat area is an advanced one, and mechanically simpler engines may be discerned. A design of fixed intake area 0·6 to 0·7, with a nozzle area varying between about 0·8 to 0·3 or 0·4 can give good thrust and economy over the speed band Mach 2 to 3·5 and also efficient reduced thrust for cruising. Finally, there is the present-day fixed-geometry engine.

Comparing the characteristics of a fixed-geometry engine with those of an engine of variable exhaust geometry: starting with equal performance at the design speed Mach 2, 20 per cent. of thrust is lost by Mach 3, specific fuel consumption is up to 20 per cent., combustion chamber pressure has fallen 20 per cent. and combustion chamber velocity has increased by 50 per cent. Diffuser air flow is disturbed and irregular patterns develop which create operating difficulties of their own, aggravating combustion problems due to low pressure and high velocity. Further increase in specific fuel consumption occurs with reduction of thrust below the maximum. However, for the fixed-geometry missile engine, weight due to mechanical complication rapidly eats up fuel saving, especially since the engine does most work at the lower speeds and altitudes where its design is relatively efficient. This type of engine is therefore entirely right for its purpose, but it is not necessarily easier to develop than the more sophisticated engines.

In a fixed-geometry engine working over a range of speed and thrust, the space distribution of mass flow from the intake varies enormously and is, sadly, beyond our ability to account for analytically. But this is not all; should the combustion system excel itself or, more likely, the control system lapse, thereby overdoing the temperature with reduction in mass flow, the intake reserves the right sometimes to go unstable.

To control distribution in the "simple" engine, an obvious method is to redistribute air physically within the intake. This can be done by a sandwich sampling scoop taking radial slices of air and delivering alternate slices to the top and bottom of the passage. For low loss, the angle of the scoops must not be too steep, and they are preferably cut-off at the downstream end to give, in effect, a short circuit for air in the mid-regions of the passage. The device can be installed in a diffuser at a plane where the mean Mach number at full recovery is about 0·35 for a loss in maximum recovery of 2 per cent.

Intake instability is a rather different issue. Should an engine inadvertently enter this region of intake operation the flame may go out, or the engine may continue to oscillate indefinitely or, it may recover with change of operating conditions. Generally, by accepting a loss of latent thrust somewhere over the flight speed band, operations can be planned to avoid the unstable region. However, a little interesting work has been done on an automatic stabiliser or "shock catcher" which can prevent the worst effects of intake instability, but which has not got the simplicity required in a missile engine.

* National Gas Turbine Establishment.

From the beginning, work at the National Gas Turbine Establishment has tried to establish a type of combustion system adaptable to the needs of both full-thrust and cruising regimes, and the constant theme has been the use and improvement of pilot systems. The idea is to divert a fraction of the air into a sheltered region, physically separated from the main flow, in which lower mean axial velocities are maintained and where fuel concentration and gas-mixing patterns can be reasonably well controlled within the pressure drop available. Having created a stable flame, efficient under all operating conditions, it is used to ignite the remaining fuel and air by-passing the pilot. This constitutes a two-stage system where thrust is altered by cutting off fuel supply to part of the by-pass air only, still leaving the cruise fuel to burn at optimum conditions throughout the thrust range. This technique is now very widely used.

In a pod-mounted engine external air flow may be used for direct convection cooling of the combustion chamber wall. Useful heat is lost overboard and the tailpipe is exposed to aerodynamic and inertia loads, but the practice is justifiable where weight is more critical than economy. It has proved possible to run regularly at overall mean temperatures of 2,100 deg. K. and ram temperatures of 200 deg. C. The mechanical design and performance of the combustion chamber, the nozzle and the cooling system must be worked out as one joint exercise, especially in view of the big part played by metal fatigue. Should fatigue failures occur as a consequence of the varied and not-well-understood air vibrations observed in all high-velocity systems, the results are often immediately catastrophic. Fig. 1 shows such a failure. Acceptable metal temperatures, thickness, and weight, and required cooling flows, are therefore really determined in the limit by observed fatigue behaviour in very complex circumstances, and it is this fact above all others which dictates the need for ground-test equipment simulating at full-scale the working densities and temperatures of flight. Fortunately, it is only at ram pressures above 3 atm. that the difficulty becomes acute and then for the durations desired in ground development, rather than for missile flight times. The rough picture is that, for the durations and flight conditions where missiles or aircraft might operate, the ram-jet just " gets away with it " without obvious weight penalties.

Until the recent acquisition of elaborate and versatile ground test equipment (described in the June 14, 21 and 28, 1957, issues of ENGINEERING), N.G.T.E. have tackled functional problems by flight trials of a Napier-built test vehicle. Fig. 2 shows the record of speeds and heights covered so far.

The test vehicle has confirmed that ground simulation techniques for the complicated dynamic process of ignition, especially at supersonic speeds, are reasonable guides to flight performance. It has forced clearer thinking on the effects of high transient g on fuel system operation. It taught a sharp lesson on the sources and cumulative performance effects of small air leakages in light construction, and the practical limitations of the most efficient boost techniques; it sponsored some understanding of the complicated kinematics of the processs; it made us learn how to install electronic equipment to work in the pressure and vibration field of the engine. Especially, it has forced the habit of precise accounting over the whole field of operation, rather than the sweeping generalisations on performance and operating factors into which research too easily slips.

Further progress turns upon variable geometry, internal compression intakes and so on, and emphasises intricate problems of control and endurance. But it must be asked, will it all be worth while?

Fig. 3 attempts to vivify the real point of a ram-jet as a true aircraft engine. In a climb at the modest speed of 500 m.p.h. it shows the decrease of fuel load and the patterns of aircraft drag and engine thrust. It presumes a reheated turbo-jet for speeds up to about Mach 2 and a variable intake ram-jet thereafter; the two engine thrust characteristics match remarkably well. Moreover, the intake and exhaust area requirements are the same for both engines at the transition speed. The intake and exhaust systems can therefore be shared, and in principle the ram-jet combustion system could be used as the reheat system of the turbo-jet. Two vital points are, the roughly constant thrust characteristics of the ram-jet, which behaves in climb and acceleration like a super-efficient rocket, and the large excess of available thrust over cruising drag. For little extra weight the ram-jet can " tack-on " to the take-off engines and deliver the aircraft promptly to guaranteed speed and height irrespective of likely aircraft weight and drag variations. By closing the exhaust nozzle at top speed the cruising s.f.c. drops to about 2·5, representing a 40 per cent. overall engine work efficiency. In descent or stand-off the ram-jet-turbo-jet combination could operate as a plain turbo-jet with adequate thrust and good economy.

If high cruising speed and operating height are wanted, the ram-jet is able to serve. But for purely economic flight high engine efficiency is useless if it can only be achieved at flight speeds involving prohibitive loss in lift/drag ratio or structural efficiency. The end point of ram-jet development, and the greatest prizes it offers, will only be achieved by a drastic change in aircraft convention.

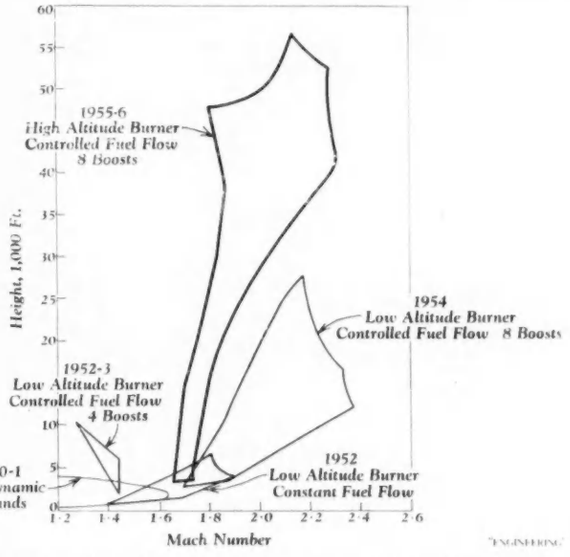

Fig. 2 Flight envelope of N.G.T.E.'s ram-jet test-vehicle trials.

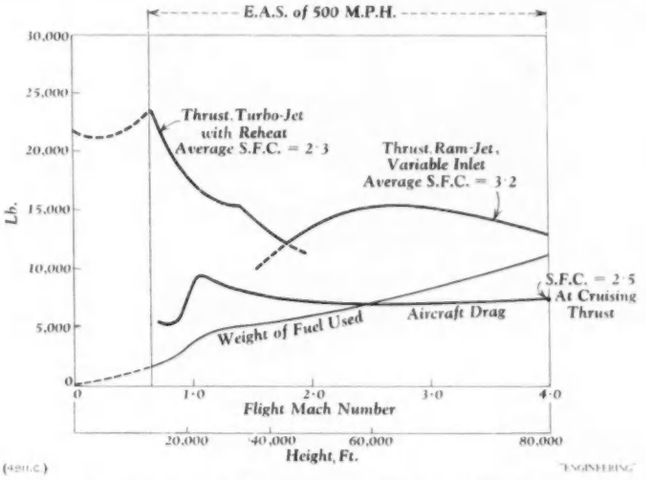

Fig. 3 Thrust, drag and fuel consumption of a hypothetical ram-jet powered aircraft of 50,000 lb. all-up weight.

CHECKING STRAIN IN POWER-OPERATED FLEXIBLE THROAT PLATES

Transducer System in Bedford Wind Tunnel

The General Electric Company, Limited, have recently released details of a comprehensive transducer system supplied to the Royal Aircraft establishment, Bedford, by their associate, Salford Electrical Instruments Limited, Salford, Lancashire. The system maintains an automatic safety check on the strain in the flexible-throat plates of the 8 ft. wind tunnel.

A description of the 8 ft. tunnel was given in the July 12, 1957, issue of ENGINEERING. It may be recalled that the supersonic throat of the tunnel consists of two 1 in. thick flexible stainless-steel plates, each 62 ft. long by 8 ft. wide. The supersonic wind speed in the tunnel is controlled by flexing each plate and so changing the shape of the throat. The flexing is performed by 60 pairs of mechanical jacks spaced equally down the length of each plate.

The transducer system gives a continuous record of the radius of curvature of the stainless-steel plate at each jacking station during operation and, therefore, the strain in the plate at this point. Sixty spherometer-type low-range mechanical displacement transducers are used, one transducer mounted between each pair of jacks. The control equipment indicates the transducer displacements on a display panel, and also includes a " routiner " unit, shown in the illustration overleaf for a complete and continuous automatic check of the whole system. Should a transducer circuit be faulty, the routiner stops and a light indicates how far the test has progressed. A telephone dial is provided on the routiner so that any jacking station in the system may be selected rapidly for test alone if required.

The spherometer transducers used in the system are from the standard Salford range. The

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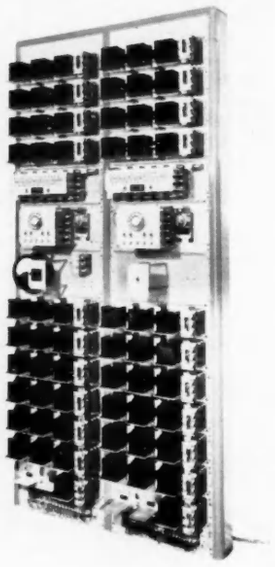
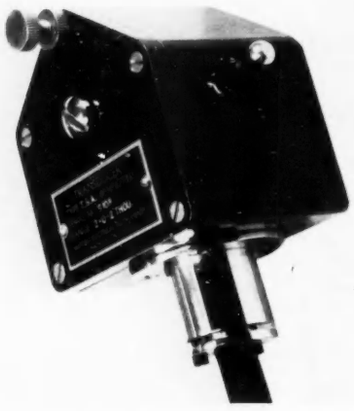
instrument, seen in the lower illustration, is designed to measure small changes in radii of curvature with a sensitivity as high as ± 0·0025 in. The head is an electromagnetic mechanical-displacement type transducer. A central stylus controls the position of a magnetic armature disc



The routiner unit, seen here with covers removed, checks the operation of the transducer circuits which automatically check the strain in the stainless steel plates of the 8 ft. flexible throat tunnel at Bedford.



The spherometer transducer measures small changes of radius of curvature to ± 0·0025 in. The head is an electromagnetic mechanical-displacement type transducer.

which is mounted in a gap between two pairs of coils. Each pair of coils is wound as a transformer and mounted in a high-permeability magnetic pot core. A constant alternating current is arranged to flow in the primary winding of each transformer, and the output of the differentially-connected secondary windings is connected to the moving coil of a special dynamometer indicating instrument. Any movement of the armature disc causes a corresponding change in the mutual inductance of the coils with a resultant increase or decrease in the current to the indicating instrument.

Book Reviews

ACCURATE MEASUREMENT

Mechanical Engineering Laboratory. By JESSE SEYMOUR DOOLITTLE. *McGraw-Hill Book Company, Inc.*, 330 *West* 42*nd-street, New York* 36, *N.Y., U.S.A.* (6.50 dols.); and *McGraw-Hill Publishing Company, Limited*, 95 *Farringdon-street, London, E.C.*4. (49*s.*)

This book, by the Professor of Mechanical Engineering at North Carolina State College, is concerned with instrumentation and its application, and is intended as a background text-book for students taking a first course in mechanical engineering laboratory work. The truism that accurate measurement is the basis of scientific discovery has its counterpart in the applied scientific field of engineering, where successful design and performance are founded on knowledge derived from accurate measurements of the physical properties of materials. It will not be disputed, therefore, that the early training of every engineer should include instructions in the general principles of measurement, the theory underlying the main types of instruments in common use, and the precautions necessary to achieve reliable results in using them. Professor Doolittle goes a stage further than this by differentiating between the study of instrumentation, regarded as an end in itself, and the application of instrumentation for determining the performance characteristics of machines and equipment. He holds, correspondingly, that the sort of instruction the student should receive and the form of the student's report on the work should differ according to whether the measuring apparatus is the sole subject of study or is used to indicate or record the results of a laboratory test in an engineering subject.

The rapidly growing number and diversity of instruments nowadays available presents any author of a course text-book on that subject with at least two difficulties that Professor Doolittle has been unable entirely to surmount. Writing primarily no doubt with his own laboratory and students in mind, he cannot, in reasonable compass, discuss the details of instruments actually used by other students in other laboratories. The second difficulty is that of knowing where to start, and what range of instruments to include. Some students and teachers, in English universities at any rate, may feel that some of the elementary matter in this generally elementary book has been adequately covered by school teaching in physics, chemistry and mechanics. Or it ought to have been: perhaps Professor Doolittle's experience has prompted him to err on the safe side! Unexpectedly, on the other hand, the book does not deal with some types of measurement—micro-metrology, mechanical testing and oscillography, for instance—that are fundamentally important in mechanical engineering.

In other respects, the first two parts of the book deal satisfactorily with laboratory apparatus for engineering measurements ranging from those of pressure, temperature and speed to power, flue-gas analysis and fuel calorimetry. The author's comments on how the apparatus should be calibrated and used, and his suggested exercises and problems are all valuable. In the third part of the book, concerned with engineering experimentation, the most useful chapters are those dealing along general lines with the conduct of tests, the analysis of data and the reporting of results. The only experiments specifically considered are measurements of fluid flow and heat transfer, and the relevant text embodies material to be found, more appropriately, in standard works on hydraulics and physics. An appendix of tabulated data is convenient for quick reference, though here again the thought persists that most of the 40 pages it occupies could have been put to better use, and the student's training extended by simply directing his attention to appropriate published compilations of data. The book, as a whole, gives the impression of being somewhat unbalanced and of hardly meeting the mechanical engineering student's needs. Quite likely his instructor will find it more useful since he may be presumed to know the factual information and can concentrate on the stimulating opinions and suggestions that are the fruit of the author's teaching experience.

IN THE PATHS OF NEWTON

Engineering Mechanics. By ARCHIE HIGDON and WILLIAM B. STILES. *Longmans, Green and Company*, 6 *and* 7 *Clifford-street, London, W.*1. (32*s.* 6*d.*); and

Mechanics for Engineers: Statics and Dynamics. By FERDINAND P. BEER and E. RUSSELL JOHNSTON, JR. *McGraw-Hill Book Company, Incorporated*, 330 *West* 42*nd-street, New York* 36, *N.Y., U.S.A.* (8 dols.); and *McGraw-Hill Publishing Company, Limited*, 95 *Farringdon-Street, London, E.C.*4. (60*s.*)

To an engineer brought up in the Cambridge tradition of Routh, Lamb and Inglis, any book on engineering mechanics has a habit of appearing to lack both insight and precision. It is probable, however, that Higdon and Stiles, now reproduced in England from the second American edition, will appeal to many teachers of the subject. The objects of the authors, as stated in their preface, are the right ones: formulae are avoided as far as possible, and analysis is emphasised.

A definite attempt is made to combine rigorous analysis with a sense that this applies to real machinery; for instance, an example shows a real fork-lift truck and its idealised representation stating the problem to be solved. The subject is started from scratch, and the ground covered, both in statics and dynamics, is adequate for most degree courses, although the chapter on vibration analysis is a little thin, and the types of problem best handled by moment of momentum are not sufficiently dealt with. An unusually good selection of examples is included, however, together with answers.

Beer and Johnston's book covers very much the same ground at almost twice the price and in many more pages. The text is perhaps rather easier to follow, and the layout of its many worked examples is particularly good.

It is interesting to note in both volumes how historical research is leaving its imprint on such works; but who among the readers of ENGINEERING feels that Varignon's Theorem needs to be called by that name?

NEW BOOKS

Collins Engineers Diary, 1958. No. 393. *Collins*, 144 *Cathedral-street, Glasgow, C.*4. (*Various bindings from* 5*s.* 3*d. to* 9*s.* 6*d.*)

Few diaries to-day are simply repositories for memoranda, and those compiled for specialists of one kind or another provide a wealth of supplementary information. The diary prepared by Collins for engineers includes some 160 pages of tables and other data, ranging from steam tables to standard threads, from bearing pressures on rocks and soils and electrical formulae to atomic weights and common integrals. No doubt the comparatively small section devoted to atomic energy will grow during the next few years as data become more consistent. A comprehensive table of contents, and the usual

public information add to the usefulness of a diary which exemplifies the art of condensation.

Oil-Fired Central Heating. By A. B. PRITCHARD. Reprinted from *The Industrial Heating Engineer. John D. Troup Limited, 90 High Holborn, London W.C.1.* (6*s.*)

The material in this booklet appeared between June, 1956, and May, 1957, and covers various types of oil burner currently in use. It also deals with the attaining of combustion efficiency, with automatic burner controls, and has chapters devoted to hot water boilers and oil-fired warm air units. The final section deals with the storage and handling of fuel oils.

Examination of Cycles Considering Variable Specific Heat. By E. JUREK. *Akadémiai Kiadó, Alkotmány-atca* 21, *Budapest V, Hungary.*

Most work on heat engine cycles is based on the comparison with ideal diagrams and, for most of these, it is sufficient to assume a constant specific heat. Where, however, it is necessary to have exact figures, the variations of specific heat must be taken into account, and this booklet by E. Jurek, who comes from the Department of Agricultural Machinery, Technical University, Budapest, lays out a full examination of heat engine cycles in which allowance for this variable is made.

Garcke's Manual of Electricity Supply. Vol. 54, 1956-57 edition. *Electrical Press, Limited,* 19-20 *Noel-street, London, W.1.* (77*s.* 6*d.*)

The volume contains the statistical record of the British electricity and allied manufacturing industries for the year 1956-1957, together with a directory of executive personnel.

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Anti-Corrosion Liquid. THE WALTERISATION COMPANY LIMITED, Waddon Marsh-way, Purley-way, Croydon, Surrey. Foscote R.S. for rusty iron and steel surfaces; Foscote A.L. for aluminium and its alloys and Foscote G.A. for galvanised steel and other zinc surfaces. Brush-on liquids, the R.S. converts thin iron rust into a phosphate coating and provides a base for paint, and the A.L. and G.A. liquids form a phosphate paint-bonding surface layer. Illustrated leaflet.

Die Castings. FRY'S DIECASTINGS LTD., Midland Works, Brierley Hill-road, Wordsley, near Stourbridge, Worcestershire. Gravity and pressure die castings are available in zinc and aluminium alloys, 60 : 40 brass, high-tensile brass, aluminium bronze, nickel aluminium bronze and magnesium alloys. Properties and applications covered in an illustrated booklet entitled *Die Castings—Your Questions Answered.*

Box-Type Electric Furnaces. G.W.B. FURNACES LTD., Dibdale Works, Dudley, Worcestershire. Electrically heated batch-type furnaces used for a wide variety of industrial heating operations. The temperature limitations are the same as for any other electric resistance furnace, the maximum range being in the region of 1,200 deg. C. Illustrated brochure.

Dry Film Lubricant. STEDALL MACHINE TOOL CO., 145-157 St. John-street, London, E.C.1. "Everlube" dry film lubricant for temperatures from − 120 deg. F. to + 1,000 deg. F. Compound is fused on to the metal part and is unaffected by most solvents. Leaflet.

Automatic Transmissions. BERG-WARNER LTD., Letchworth, Herts. "Mr. Jones Bags Automatic" booklet fascimile of a filmstrip which is available on loan together with a 33 r.p.m. sound record describing the manufacture and operation of the automatic unit.

Engine Test Equipment. NEWAGE (MANCHESTER) LTD., 6 Carlos-place, Grosvenor-square, London, W.1. Testing equipment for internal combustion engines designed for college laboratories. Complete plant with all measuring equipment for various sizes of engine. Illustrated brochure.

Miniature Ball Bearings. MINIATURE BEARINGS LTD., 39 Parliament-street, London, S.W.1. R.M.B. miniature ball bearings from 0·5 to 10 mm. bore, radial, thrust, angular contact and pivot types, load capacities, tolerances, cleaning and lubrication. Illustrated catalogue.

Pneumatic Equipment. CLIMAX ROCK DRILL AND ENGINEERING WORKS LTD., Carn Brea, Redruth, Cornwall. Valves, cylinders, drills, lubricators, fittings and control gear for all types of Maxam pneumatic equipment. Comprehensive loose leaf catalogue.

Aluminium Sheets for Permanent Awnings. NORTHERN ALUMINIUM CO., LTD., Banbury, Oxfordshire. Noral "Industrial" corrugated aluminium-alloy sheets for ships' permanent awnings. Illustrated brochure of technical data, installing recommendations and typical recent applications.

Sectional Materials. HALL HARDING LTD., Stourton House, Dacre-street, London, S.W.1. "Alliance" brand sectional pads, graph paper, ruled drawing sheets, isometric paper, Gantt charts and the like. Catalogue of samples, types and prices.

Brakes. FERODO LTD., Chapel-en-le-Frith, Stockport. Comprehensive bound catalogue of brake linings, shoes, clutch facings and plates, fan belts and tools. Types are listed for all makes and models of road vehicles.

Grading Sieves. SOILTEST INC., 4711 West North-avenue, Chicago 39, Illinois, U.S.A. Electrically driven shaker sieves for materials testing and gradation. Models and accessories. Leaflet.

Railcars. SELF-CHANGING GEARS LTD., Lythalls-lane, Coventry. "Railcar Progress around the British Isles" describes developments under the modernisation plan and includes photographs and drawings of most types. Booklet.

Air Spaced Cables. TELEGRAPH CONSTRUCTION AND MAINTENANCE CO. LTD., Mercury House, Theobalds-road, London, W.C.1. Characteristics and dimensions of semi-air spaced coaxial cables. Leaflet AS/2.

Marine Pipe Work. CHARLTON, WEDDLE & CO. LTD., Manors Works, Newcastle-upon-Tyne 1. Marine pipe work in aluminium, brass, iron or steel. Brochure gives nature of products and services of a new company.

Hydraulic Variable Speed Gears. CARTER GEARS LTD., Bradford 3, Yorkshire. Features, forms and ratings of type A hydraulic variable speed gears. Torques from 77 to 1,450 lb.-in. Booklet A/3.

Indicator Lights. WILLIAM MCGEOCH AND CO. LTD., Bordesley, Birmingham 10. Panel fittings, mountings and holders for indicator lights; catalogue of types and sizes.

Diesel Engine Exchange Service. W. H. DORMAN & CO. LTD., Stafford. Site exchange plan for replacement of parts or complete engines. Booklet gives particulars.

Diesel Locomotives. DAVEY, PAXMAN & CO. LTD., Standard Iron Works, Colchester. A pictorial review of locomotives which were fitted with the firm's engines during the last 25 years. Brochure No. 1528.

Hydraulic Pumps. FIELDING AND PLATT LTD., Atlas Works, Gloucester. Pumps for hydraulic systems, presses and the like. Dimensions, capacities and applications. Booklet.

On the Shelf

By Frank H. Smith

The news-sheet of Convair, the aircraft company, *Convairiety*, announces that as an economy measure the publication is to be reduced to six pages. In future, the photographic coverage of 15-year and 20-year service presentations will be cancelled and only 25-year presentations will be covered. I suppose this has some significance to economists but it strikes me as being a small contribution to economy.

The UNESCO Monthly *Bulletin* on Scientific Documentation and Terminology continues, in the November issue, its lone campaign to reduce the number of conferences. A Mr. Wagner of the American Celanese Corporation has some particularly pungent comments which boil down to the fact that those who get on with their work have no time to talk or write about it. He finishes: "Going to a scientific meeting does not insure that one will return any different than one was before, except, perhaps somewhat more fatigued."

Consultants Bureau Incorporated, 227 West 17th-street, New York 11, U.S.A., have issued their "Catalog No. 2" on "Russian Research in the Physical Sciences." A foreword on the inside cover states: "Scientific achievement knows no national boundaries. Don't duplicate research. Russian research is available to you in complete, scientifically accurate, English translation." This may be true but I have a nasty feeling that there *is* duplication in this very field. Everywhere there is evidence of people going bald-headed at Russian translation and if only this country and America could establish one central non-commercial bureau there need be no duplication of very expensive translation of highly technical material. The longer this is delayed the greater will be the wastage.

The National Trade Press, Drury House, Russell-street, Drury-lane, London, W.C.2, announces "the only book to cover in full the subject of artificial fibres." It is *Man-made Fibres*, by R. W. Moncrieff and costs 65*s.*

I sometimes wonder how those people who send out circulars get hold of names and addresses. The Telephone Directory is, of course, one source and so are the various other directories of trades, professions, etc. That is why most societies will not distribute lists of members except to their members. It is a pity that valuable works of reference can be abased in this fashion but I believe that the menace is not so great in this country as it is in America. The publishers of, for instance, *Encyclopaedia of American Associations*, Gale Research Co., 1116 Book Tower, Detroit 26, U.S.A., must be a godsend to makers of office equipment, labour-saving devices and office stationery. Another 6,000 addresses to add to their addressograph.

The American aeronautical industry is particularly well-served as far as one, at least, reference work is concerned. Where most industries count themselves lucky to receive one directory a year, the *World Aviation Directory*, American Aviation Publications, Incorporated, 1001 Vermont-avenue N.W. Washington 5, appears twice. The Fall/Winter 1957-8 edition at 10 dols. has just been received and it is a mine of information, not only on the American industry, Government departments, individuals and so forth, but also on other countries' organisations. The directory does not, of course, deal with the aeroplane *per se* and the buyers guide section will interest a much greater audience than is implied by the book's title.

Many listeners and viewers must envy persons possessing an apparently inexhaustible fund of funny stories. Imagine the joy of making an after-dinner speech and having every listener rolling with laughter. This, it seems, is within every man's reach. A. Thomas and Company, 25 Glovers-court, Preston, have published *The Treasury of Modern Humour*, by M. Lupton, at 42*s.*; it contains 2,500 new funny stories, 500 toasts for all occasions, 24 clever ways to introduce a speaker (I wonder if this includes bringing him out of a hat?), 18 humorous responses and 2,000 deft definitions. This book I must have.

In January will appear *Molecular Physics*, obtainable from Taylor and Francis Limited, Red Lion-court, London, E.C.4, or, in the United States and Canada, from Academic Press of New York. The folder advertising this quarterly, which will be another of these fashionable English/French/German affairs, at £4 15*s.* per volume, invites suggestions on the future policy of the journal and the fields which it might cover.

Interscience Publishers Incorporated apparently consider that there are enough people interested in pest control to justify the publication of a two-volume work on *Advances in Pest-Control Research*. Only the first volume is published this year and it is edited by R. L. Metcalf, of the California University Citrus Experiment Station; it costs 11 dols.

Design

TURBINE POWER FOR SHIPS

We give below abridged extracts of the first de Laval Memorial Lecture, delivered in Stockholm in September by Dr. T. W. F. Brown, Research Director, Pametrada Research Station. This lecture has been founded to commemorate the work of Dr. Carl Gustav Patrik de Laval, who developed, nearly 75 years ago, the first practical steam turbine in the world. The latter part of Dr. Brown's paper, on nuclear reactors for marine propulsion, has already been dealt with in Atomic Review, October 4 (page 444); November 1 (page 569); and November 29 (page 698).

The performances of four types of ships are selected for review: cross-channel steamers, destroyers and escort vessels, liners and cargo liners, and oil tankers and ore carriers.

Cross-channel ships are usually lightly-built but weatherly, with high power in relation to displacement. Such ships spend only a short time under way per year, say, 10 to 20 per cent. The main requirements, therefore, are small stand-by losses, certain manoeuvring, full power must be reached quickly, and the machinery must be capable of considerable astern running. High steam temperatures and elaborate feed systems cannot be employed, as the ships do not run long enough for the temperatures to be developed and the system to settle down. Pressures between 350 and 450 lb. per sq. in. and temperatures of 650 to 750 deg. F. are adequate. Concentration in design is consequently on simple rugged turbines, able to use a good vacuum and with plenty of astern power. This is a field in which a comparatively simple gas-turbine would be particularly suitable in low powers, as the complexity of heat exchangers, etc., is unnecessary. Fuel consumption is secondary, but weight and space are usually at a premium. For high powers, with inlet temperatures to the turbines of about 1,250 deg. F., a compound cycle with two stages of compression, intercooling, and possibly reheat would be required to reduce the sizes of the power units and of the air ducts and openings.

Varied Shipping Needs

A destroyer, on the other hand, spends a very short time at full power. American figures for usage show that power above 20 per cent. of the full power is used for less than 4 per cent. of the operating life of the ship. It is because of this that a combination of a steam cruising turbine with gas boost turbines to give full power has been proposed and built for naval use. Economy at low powers is of paramount importance, with the ability to build up to full power quickly when required. Under this condition, the time is so short that maximum fuel economy is not very important; for example, the vacuum can be allowed to drop back to, say, 26 in., to reduce the low-pressure turbine and condenser sizes. Manoeuvrability from very low powers to high powers and back again at any required rate and, at times, with great frequency, is essential. Light weight with absolute reliability is required, and the ability to sustain shock loads and battle damage must be designed into the machinery; and accessibility must be striven for, even against the incompatible requirements of minimum space.

Liners and cargo liners are usually used on long and relatively high-speed runs, operating to a close schedule, and generally spend some 40 to 60 per cent. of their time at sea. While reliability is a prime necessity, the machinery installation is complicated by the requirements of "hotel" loads—electric galleys, lifts, lighting, and, now, more extensive air-conditioning to suit all climates. With the large hotel loads affecting the overall fuel consumption, there is a tendency in Britain not to proceed to the most advanced steam conditions for the turbines, though there are notable exceptions.

Tankers are the largest class of ship at present building in the world. Also, they have been increasing steadily in size since the war. In 1921, the largest tankers were of 22,600 tons deadweight; in 1948, 26,600 tons; in 1952, 31,900 tons; in 1953, 45,300 tons; in 1956, 85,500 tons; and in 1957, 100,000 tons. The largest tankers shown for 1956 and 1957 are, however, unlikely to become normal, and the usual upper limit would appear to be around 65,000 tons deadweight.

Tankers and ore carriers have the greatest usage of any class of ship, as they are engaged in general on long hauls. They have quick loading and discharging facilities on board and at the terminal points in their voyages. Shell Tankers Limited report, for some ships in two sizes of the tankers in their fleet, that the usage is 67 per cent. for the smaller ships and 81 per cent. for the larger ships. Another company state that the average yearly total steaming time at normal service power is 280 days. Out of the remaining time between 14 and 28 days are spent without steam raised during repairs and dry-docking, and the rest is divided between port time, pilotage, awaiting berths, etc.

Steam Turbine Designs

The powers required, according to present inquiries for steam-turbine designs, vary from 7,500 s.h.p. for ships of 18,000 tons deadweight to 22,500 s.h.p. for those of 60,000 tons. These are for single-screw propulsion installations, as the big ships under construction show only a slight increase in speed over their smaller sisters.

The maximum main gearwheel diameter should not in general exceed 165 in., as this represents the point at which rim forgings are special. Only three firms in the marine industry in Great Britain have gear-hobbing machines which can accommodate larger wheels. Stiffness of gearcases, thrust blocks and seatings is especially important, and the limit on main-gear diameter assists in producing a compact and rigid gearcase. With the given size of main wheel, a normal gearbox has primary wheels up to 85 in. in diameter for articulated gears, and about 60 in. for locked-train gears. The usual revolutions adopted are 110 per minute. The upper power which can be transmitted in standard designs is 29,000 s.h.p. at 110 r.p.m. for plain articulated gears; with locked-train gears the limit would be 45,000 s.h.p. on one shaft at 120 r.p.m.

For twin-screw tankers the power per shaft could be even greater, as the main-shaft r.p.m. would increase and still operate at maximum propeller efficiency. The largest tanker at present building in the world (for Mr. Stavros Niarchos) has a deadweight capacity of 106,500 tons. Her length is 940 ft., breadth 134 ft., and loaded draught 49 ft. The shaft horse-power is 43,000 (two screws) and the loaded speed will be 18 knots. At 16 knots the power would be about 30,000 at 115 r.p.m. and the propeller diameter about 24 ft. Single-screw propulsion would be entirely feasible and probably would give a better propulsive coefficient than twin screws at this lower speed. For higher powers it would be advisable to use twin-screw machinery from the point of view of propulsion and propeller size.

A few tankers of a special class have been built which can trade in peace-time at 14,000 s.h.p., with a normal overload to 15,000 s.h.p., but in which live steam can be admitted after the eighth stage in the high-pressure turbine to give a maximum service power of 22,500 s.h.p., with yet a further 10 per cent. overload margin. The steam conditions are 600 lb. per sq. in. and 850 deg. F. at the superheater outlet, with 28·5 in. vacuum at normal service power, falling to 27·85 in. at maximum overload, with the sea water at 75 deg. F. Thus, with only a minor modification to the turbines, a maximum of 78 per cent. increase in power is obtainable. The ratings of the boiler and gearing become higher than normal at maximum overload, but if these high overload powers are only required in emergencies, after the machinery has been run in, it is considered that they can be safely achieved. In considering the nuclear propulsion of ships, it is suggested that similar by-pass arrangements should be provided in the turbines to enable the advantages of greater heat output from the reactor to be utilised in the turbine machinery as improvements become available in the reactor. The steam turbine is the only type of machinery in which high overloads of this nature can be provided with a very small increase in the total weight, and with no effect on the efficiency at the normal designed power.

Future Gains

The question may well be asked, what further gains are expected in the consumption of oil fuel by steam-turbine machinery in the future? The following table summarises the gains for 20,000 s.h.p. machinery in overall oil rates at higher inlet conditions, with and without reheat. Increase of pressure with temperature follows naturally, as it reduces the size of the hot parts of the high-pressure turbine and provides a greater heat drop, without too much wetness at the low-pressure exhaust.

Inlet conditions			Oil rates, lb. per s.h.p. per hour	
Pressure, lb. per sq. in.	Temperature, deg. F.	Reheat temperature deg. F.	Straight cycle	One reheat point
650	950	Nil	0·500	—
650	950	950	—	0·480
950	1,050	—	0·480	—
950	1,050	1,050	—	0·458
1,100	1,200	—	0·462	—
1,100	1,200	1,050	—	0·445

At the 1,050 deg. F. temperature conditions, an astern turbine might be fitted with attemperated steam for manoeuvring. However, with reheat at 1,050 deg. F. and in the last two cases, with inlet steam at 1,200 deg. F., it is considered that either hydraulic transmission or epicyclic gearing, in conjunction with unidirectional turbines, would be essential. The boilers also, particularly with high-temperature reheat schemes, should be closely adjacent to the turbines; to achieve which, pressure-combustion boilers (operating at a furnace pressure of, say, 4·5 atmospheres) would be particularly suitable, due to their small size. A unidirectional turbine operating at 1,100 lb. per sq. in. and 1,050 deg. F., has been under test at the Pametrada Research Station for a number of years. Little trouble has been experienced.

Uses for New Materials

Coupled to improvements arising from considerations of critical speed, elimination of astern turbines, and the use of hydraulic transmission or epicyclic gearing, are detailed improvements in the efficiency of blading and nozzles, the use of spring-backed glands and fins which prevent rotor-bending even if a touch should occur, the use of improved bearings (especially thrust bearings) to minimise loss, and the use of new materials as they become available. For low-pressure blades, titanium has extremely good resistance to both corrosion and erosion. Because of its lower density compared with stainless iron and the avoidance of the need to fit tungsten-carbide shields, etc., it forms an ideal blade for the last rows in a low-pressure turbine, enabling the rotor to run faster without increase in stress. Though blades formed from titanium would be considerably dearer than those of normal materials, the overall effect would be to cheapen the cost of the whole turbine.

At higher temperatures than, say, 1,450 deg. F., the gas-turbine, particularly with liquid cooling, should be available. It might even be ready before high-temperature gas-cooled reactors are developed to provide the operating fluid at the appropriate temperature of 2,200 deg. F.

SILENCING AIR CHANNELS

Attenuation in Rock-Wool-Lined Ducts

By A. J. King, M.SC.TECH., D.SC., M.I.E.E., F.INST.P.*

A previous paper[1] contained curves giving the attenuation of sound with frequency in lined ducts of various widths and thicknesses of lining of rock wool. Subsequent experience has shown the need for an extension of these curves to cover thicker linings and splitters, and advantage has been taken of an opportunity to obtain further data on 16 in. splitters and air channels. New curves including these data are given for 50 per cent. space factor, together with an extrapolation to 32 in. splitters. Thicknesses greater than 16 in. are unlikely to be used unless frequencies lower than 100 cycles per second are important. For covering very wide frequency bands, two-stage filters are recommended.

The design of silencers of the straight lined duct and splitter types is rendered difficult by the considerable disagreement between the various methods and formulae available for predicting the attenuation, and by the scarcity or, in many cases, absence of data on the acoustical impedance or absorption coefficient of the absorbent material it is proposed to use. It is therefore useful to have available the results of experimental determinations of attenuation under typical practical conditions, together with indications of the effect of the various parameters on the attenuation, in order to be able to adapt the results to particular cases.

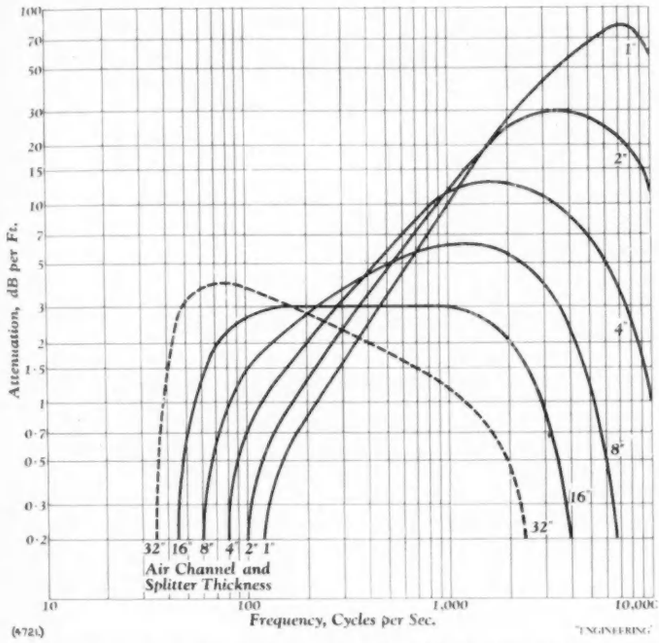
A previous paper[1] gave curves showing the attenuation of sound with frequency in air ducts fitted with absorbent linings or splitters of rock wool of various thicknesses. It was shown that the attenuation varied with the frequency, width of air channel and thickness of absorbent in the following ways. For a given absorber and air channel, the attenuation increased steadily with frequency up to the point where the wavelength became less than about two-thirds of the width of the air channel. Above this frequency, the attenuation fell rapidly owing to the increasing tendency of the sound to keep to a beam down the air channel, and not to flow laterally to the absorbent surfaces. For a given frequency and thickness of absorbent, the attenuation increased as the width of the air channel was reduced, the relation being approximately an inverse one at medium frequencies. Finally, for a given frequency and air channel, the attenuation at low frequencies increased with the thickness of the absorber, a thickness of a quarter of a wavelength giving an optimum absorption coefficient and attenuation.

These leading characteristics, which are in general agreement with theory, must be borne in mind when designing a silencer to give a certain desired attenuation-frequency performance. In addition, it is usually necessary to consider the practical aspects of size and cost, which are directly related to the ratio of thickness of absorber to width of air channel. Calling this ratio r, the effective cross-section e of a silencer available for air flow is $e = \frac{1}{1+r}$ of the total. Unfortunately, the above requirements for good attenuation, namely narrow air channels and thick absorbers, lead to high values of r and low values of e and so, inevitably, to larger and more expensive silencers. The possibility of permitting an increased velocity of flow and loss of head in the silencer, and so reducing the cross-section, need not be considered here as that step could be taken in any case.

In general, therefore, it is necessary to effect a compromise between the conflicting considerations of size or cost and performance in determining the effective cross-section to be used, and the choice is naturally dependent on local controlling factors. However, considerable practical experience has shown that, in the majority of cases, values of $r = 1$ and $e = 50$ per cent. are appropriate. Attenuation curves for this condition were given in the previous paper for air-channel widths and absorber thicknesses of 1 in. to 8 in., it being remembered that two linings are equivalent to one " splitter " absorber. In using this data it became apparent by extrapolation that increased attenuation at low frequencies could be obtained by using absorbers thicker than 8 in. This expectation was supported by measurements[2] of wave velocity in rock wool which, due to increasing movement of the fibres and isothermal compression of the air, showed values decreasing with frequency from 300 metres per sec. at 4,000 cycles per sec. down to 120 metres per sec. at 100 cycles per sec., a quarter wave for optimum absorption at the latter frequency being, therefore, 30 cm. or 1 ft. Subsequent experience with splitters 16 in. thick[3] confirmed the improved attenuation at low frequencies and new curves incorporating the old and new data for 50 per cent. effective cross-section are given in the accompanying illustration. The opportunity has been taken to change to a log-log form of presentation as this facilitates covering the wide range of values and, by making clearer the family nature of the curves for doubling air channels and splitters, permitted a few departures from regularity caused by experimental errors to be recognised and rectified.

By plotting a series of curves of attenuation against width of air channel and thickness of splitter for particular frequencies it was possible to extrapolate to 32 in. and to derive the broken curve. Assuming this curve to be correct, it appears that only if it is essential to increase the attenuation at frequencies below 100 cycles a little at the expense of reduced attenuation at all higher frequencies is it advisable to increase the air channels and splitters beyond 16 in. For other cases the curves permit a choice of dimensions to be made to provide a silencer with any desired attenuation/frequency characteristic. If it is essential to provide high attenuation over the whole audio-frequency range, as in the case[3] quoted above, it has been pointed out[4] that the necessary combination of narrow air channels for the high frequencies and thick splitters for the low frequencies would result in a very low effective cross-section and so a large and expensive silencer. However, by adopting a two-stage filter[3] the required performance can be met. The combination of 3 in. and 16 in. splitters and air channels proved to be very satisfactory in the case quoted, and the new curves confirm the choice. Other combinations may be necessary to suit particular requirements, but alternative solutions can be readily deduced from the curves and the most satisfactory from all points of view can then be chosen.

The author wishes to thank Dr. Willis Jackson, F.R.S., M.I.E.E., Director of Research and Education, and Dr. J. M. Dodds, O.B.E., M.I.E.E., Manager of the Research Department, Metropolitan-Vickers Electrical Company, Limited, for permission to publish this paper.



Attenuation of sound in lined air ducts with a 50 per cent. space factor.

Lined with rock wool, 6-9 lb. per cub. ft.
Lining thickness = half width of air channel.
Splitter thickness = width of air channel.

* Research Department, Metropolitan-Vickers Electrical Company, Limited.

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LUBRICATION COURSE FOR SENIOR ENGINEERS

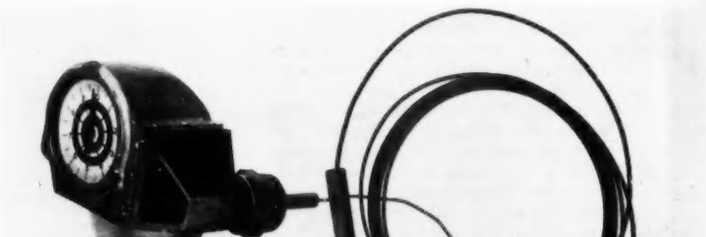
As a result of research in the universities and in specialist organisations, a fund of knowledge on lubrication has been built up which has not yet been absorbed by the general engineering industries. As a start to remedying this situation, the Mechanical Engineering Department of the City and Guilds College are organising a short intensive post-graduate course on " Engineering Aspects of Lubrication," from Monday, January 27, to Friday, February 14, 1958. It is intended for engineers who have been in industry for some years—men of about 28 to 35—and who have the status of, say, assistant chief designer in an engineering department. No mathematics beyond G.C.E. level will be involved. The course will be limited to 30 students, and the fee is 25 guineas.

About half the lectures will deal with the theory of fluid-film and thin-film lubrication, the remainder covering mainly the materials used—the properties of natural and synthetic oils and additives, greases and solid lubricants. Porous metal bearings, and the choice of bearing metals will also be discussed. The course will include tutorial and laboratory work.

Further particulars may be obtained from the Deputy Registrar, City and Guilds College, Exhibition-road, London, S.W.7.

Continuing **Design**

Thrust platforms, designed to take the thrust from an undercarriage unit, permit the static thrust of engines installed in an airframe to be measured during ground running.



An airborne thrust meter in which the thrust-measuring capsule is installed in the engine mounting trunnion thus indicating the engine load on the airframe attachment.

MEASURING INSTALLED AERO-ENGINE THRUST

To determine the static thrust of a power plant installed in an airframe, which is often appreciably different from that measured on the test-bed, thrust platforms designed to take the load through the undercarriage have been developed by a B.O.A.C. engineer, Mr. F. S. Saunders, and are being made and marketed by Alltools Limited, 2 Transport-avenue, Great West-road, Brentford, Middlesex.

The two platforms shown in the accompanying illustration are each capable of receiving a single-wheel type undercarriage unit of aircraft up to 40,000 lb. in weight, and will measure thrust up to 14,000 lb. per platform. Larger platforms are available for twin-wheel or bogie undercarriage units of aircraft up to 200,000 lb. in weight and of total thrusts up to 1,000,000 lb.

To carry out a run, all that is necessary is to place the platforms against a suitably strong abutment on a level floor, and to pull the aircraft on to them by tractor. The thrust meter, which has an accuracy of $\pm$ 5 lb. in 14,000 lb. (certified by the National Physical Laboratory), is separate from the main platforms and is adjustable, up and down, for the centre-line of the axle against the chock; it is supplied with a length of flexible capillary and detachable couplings for remote reading.

Runs have been made satisfactorily with all varieties of engine position; either inboard of the main undercarriage, or outboard, or installed in the fuselage; and either singly, or in pairs; all these conditions have been checked by running the engines independently, and then together. The apparatus is approved by the Aeroplane and Armament Experimental Establishment.

Mr. Saunders has also designed an airborne thrust meter, shown in the second illustration, in which the thrust-measuring capsule is installed in the engine trunnion so that the engine load on the airframe attachment is measured. The thrust is transmitted from the pressure capsule through detachable capillary couplings and a capillary to an instrument in the pilot's cockpit. Being self-contained, it is equally suitable for installation as a torque meter on propeller-turbine power plants. This instrument, too, is being made and distributed by Alltools Limited. A 15 ft. installation weighs 8¾ lb. and has an accuracy of $\pm$ 5 lb. on a 14,000 lb. thrust meter (N.P.L. approved); to provide a 5 lb. incremental reading of $\frac{1}{8}$ in. on a 3-in. dial, the indicating instrument has three pointers. On test for more than 12 months including both normal running conditions and afterburning tests, the thrust meter units have given satisfactory and consistent results.

POWER CABLES WITH WATER COOLING

Water-cooling equipment, which is designed to increase the carrying capacity of each of four 115 kV cable circuits from a nominal 140 MW to 215 MW, and thus to control temperature rise as the load increases, is being installed by the Hydro-Electric Power Commission of Ontario under the Humber River-Strachan-avenue section of Lake Shore Boulevard on the outskirts of Toronto. Each circuit consists of three cables with a hollow copper core 0·5 in. in diameter, the interior of which is filled with oil at a pressure of about 15 lb. per sq. in. This hollow core is insulated by oil-impregnated paper, which is covered by a metal sheath. This sheath, in turn, is covered by a coating of rubber bitumen and a wrapping of jute. The overall diameter of each cable is about 3 in. and the weight 10·4 lb. per ft. The cables are laid in a trench on a bed of sand 3 in. deep which has been specially selected to assist the dissipation of heat and with each set of three are associated two polyethylene pipes with an internal diameter of ¾ in. Town water is to be pumped into these pipes every 1,600 to 2,000 ft. and discharged into the sewers when it will be replaced by a fresh supply. Laboratory experiments indicate that its temperature should not be raised by more than 10 deg. when the cables are fully loaded. Special fittings are installed at both intake and discharge points and plans are also being made for the installation of an electronic control system so that the water flow can be started when the cable temperature reaches a certain value and be cut off when a safe temperature has again been reached. Under roadways and a railway embankment, where the ¾ in. piping was too large to fit into the asbestos-type cable ducts, lengths of ½ in. piping, two of which were encased with each cable, have been used.

The total length of cable laid is 41·5 miles with which 37 miles of polyethylene piping are associated. The manufacturers were the Canada Wire and Cable company who were also responsible for awarding sub-contracts for trenching and laying the circuits. The latter operation was not without its difficulties as attention had to be paid to the position of other underground services and ducts had to be installed under roads and railway tracks to reduce any interference with the flow of traffic. In a particular case four tunnels had to be driven under a railway embankment for a distance of 320 ft. and these had to be heavily reinforced before the cables could be placed in the concrete ducts. In the Canadian National Exhibition Grounds a 2,500 ft. concrete roadway had to be removed and replaced; and a new floor had also to be built under one corner of the Art Gallery Building. The project is a further example of the attempts that are being made for economical reasons to improve the use of material.

MIST INJECTION AND DIESEL ENGINES

A report on some research work carried out at the Pennsylvania State University was presented at the recent S.A.E. National Diesel Engine Meeting in Cleveland by Mr. M. Alperstein, Mr. W. B. Swim and Mr. P. H. Schweitzer. It deals with the effects of introducing a portion of the fuel charge of a Diesel engine into the intake manifold in the form of a fine mist. Tests were carried out on a single cylinder CFR engine with a Ricardo Comet type swirl chamber and on a Petter single-cylinder air-cooled AVA-1 engine.

Supplementary fuel was introduced by four different methods, a mist generator, a commercial pneumatic spray nozzle, a carburettor and a vaporiser. For all fuels tested, the first gave the greatest improvement, but the differences decreased as more volatile fuels were used. The mist generator was an experimental model of the commercial Micro-Fog lubricator made by G. A. Norgren. It had the disadvantage that it required the greatest air supply of the four methods, but it produced a mist with drops of under four microns.

Smoke reductions of up to 80 per cent. and an increase in smoke-limited power output up to 18·5 per cent. were obtained, together with a decrease in specific fuel consumption of 9·8 per cent., shorter ignition lag, a lower maximum rate of pressure rise and a generally quieter operation. When using Diesel fuel, approximately 15 per cent. injected into the manifold seemed to be the optimum. In another series of tests, the effect of the mist injection of a volatile fuel when using a heavy fuel of low cetane number for the main charge, was tried and it was found possible to run the engines on fuels which would not normally give steady running.

Production

THE DEXTA LINE

In order to produce their new tractor, the Dexta, the Ford Motor Company, Limited, Dagenham, Essex, carried out a tooling programme that cost about £4½ million. Of this, far the greater part was spent on machine tools.

The Dexta was described in our issue of December 13, page 741, and made its first public appearance at the recent Smithfield Show at Earl's Court. It has a three-cylinder engine developing 32 h.p. at 2,000 r.p.m. and therefore offers a smaller tractor than the Major to those who desire it. It is primarily intended for agricultural applications.

To carry out the machining operations, nearly 700 new machines were purchased, of which over 500 were tooled by the suppliers, the majority being standard machines, and 60 were specially designed for this purpose. The remainder were supplied untooled, and the special tools for them were designed and made by the company. Some were imported from America, France, Germany, and Switzerland, but many are of British manufacture, including all the gear-cutting machines and many of the transfer machines in the heavy milling section. In order to save production costs the final assembly of the Dexta will be carried out on the Major production line.

The transmission section occupies three lines each 300 ft. in length. For the transmission housing there are two American automatic in-line transfer machines with 20 stations each, for carrying out 158 separate operations in all. Power is supplied from 40 electric motors with a total of 250 h.p. For the rear differential housing there are 46 stations, again involving 158 operations, and requiring 330 h.p. from 50 motors. On the third line, which handles the clutch housing, there are two machines having 39 stations for the 93 operations involved. The power requirement here is 140 h.p., supplied by 20 motors. In another section a six-station transfer machine performs all the operations on the front axle beam.

The transmission gears and other cast-iron housings are handled by rotary index-drilling machines while the rear-axle housing and shafts, the differential casings, and the hydraulic power lift cross-shafts are drilled on horizontal drum-type machines. One notable departure from common practice is the use of British-made high-speed gun drilling equipment for the cast-iron hydraulic gear.

The feature of the transfer machines and their location is that parts pass from one to another by sliding, and hoist loading is avoided. In fact the only hoists used are those for unloading the rough stock monorail and for loading the finished parts on the monorail which feeds the assembly line. Before reaching the latter, all parts are thoroughly washed. Underground conveyors remove all the swarf and chips.

This 20-station machine is in the rear-axle housing line. All machines are electro-hydraulically controlled from remote panels.

The main shop of Frederick Town and Sons has been extended to increase the production capacity by 25 per cent.

RADIAL DRILL PRODUCTION

The production capacity of Frederick Town and Sons, Limited, Halifax, who have been making radial drills since 1903, has just been increased by an addition to the floor area of their main shop. The previous area was 120 ft. by 120 ft., and this has been enlarged to 200 ft. by 120 ft., giving an increased potential capacity of nearly 25 per cent. At the same time, a new high-pressure hot-water heating system has been installed, utilising Allen Heatwave radiators. These are supplied from an automatically stoked Cochran boiler.

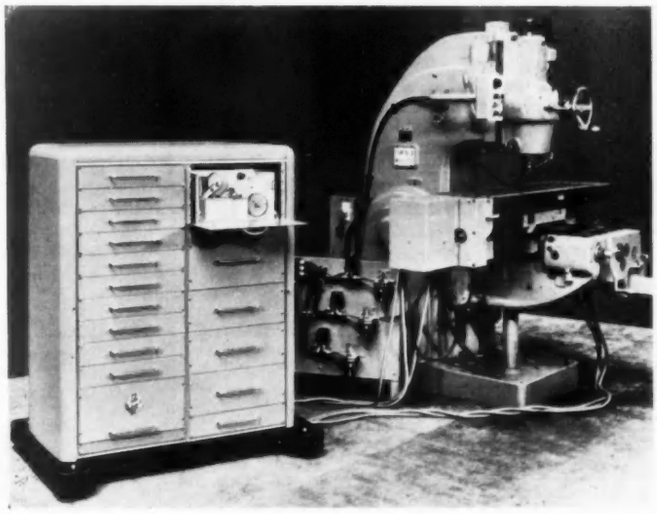
New machine tools installed include two Swift Summerskill planers, one of which has a work capacity of 8 ft. by 3 ft. 6 in. by 3 ft., and the other of 18 ft. by 5 ft. by 5 ft. These two machines will enable almost all the requirements of the firm to be met from their own sources. In 1954, the company, which had been a family concern, was taken over by Thos. W. Ward Limited, of Sheffield. Deliveries at the moment are of the order of 12 to 14 months, and approximately 65 per cent. are for the overseas market. Canada and the United States are among the main customers, with South Africa, Australia and India also on the order list. There is sufficient ground available at the site to double the present size of the building.

TAPE CONTROL

The latest application of the tape control system developed by E.M.I. Electronics Limited, Hayes, Middlesex, was demonstrated recently with a vertical milling machine of Kearney and Trecker design built by C.V.A. Jigs, Moulds and Tools Limited, 7 Buckingham-road, Brighton, 7. The model is the 2CES, which has been modified to take the control system. The complete equipment is shown in the illustration.

The control system consists basically of a punched tape which carries the co-ordinates of points on the work surface or of hole centres taken from a drawing, and a reader which interprets these co-ordinates and feeds the information to the control cabinet. A system of balanced voltages is then brought into action between the motors operating the lead screws of the table and a reference in the control unit. The reader takes groups of three points at a time and by means of quadratic interpolation selects the curve to pass through the points. A compensating system for change of cutter size can be incorporated, allowing corrections to be made manually for wear in the cutter. The great feature of the control system is that no separate computer is required. Refinements have been incorporated in the mechanism of the machine to eliminate backlash and to give a table position to within ± 0·001 in. of the true position as instructed by the tape.

Examples were also shown of the application of the control system both by tape and by manual dial setting to an Atlantic drilling machine and to a router. On repetition work such as drilling panels, an immense time saving is obtainable over the process of marking out and hand-drilling from the drawing, and considerable cost saving over the preparation of a jig, for which there might only be limited need.



The most recent application of the E.M.I. punched tape control system is to a Kearney and Trecker milling machine.

Engineering at Home

UNDERFOOT WOOD

Put your foot down in the average home and its weight will be borne by wood—a popular floor material. Its natural resilience and high thermal insulation give comfort and warmth, while beauty of grain, texture, and colour make it pleasant to look at. However, not all wooden floors are exposed.

Two types of floor are common—the ordinary board floor, and the wood block or parquetry floor. Many timbers are available for each. Three main factors govern the choosing of a wood: appearance, resistance to wear, and dimensional stability. The first two are of little importance to the board floor overlayed with some sort of carpet or linoleum. The third is important to all wood floors. Its absence presages floorboard "movement" and the presence of creak.

Timbers vary in their ability to withstand abrasion. Hardwoods show the greatest variation. Some keep their smoothness of surface, others become rough. The roughness may take several forms: a slight lifting of surface fibres along the grain; a cracking around the medullary rays when they are prominent—as in truly quartered oak, shown in the illustration*; a surface roughening along the zones or bands of interlocked grain—prominent in many tropical woods when quarter sawn. Severe lifting of the surface fibres leads to splintering.

The way softwoods wear depends on how they are sawn up. Rift sawn or quarter sawn material, with growth rings meeting the surface at an angle not less than 45 deg., becomes ridged or serrated on the surface. Flat sawn material, with its rings meeting the surface at less than 45 deg., breaks down in the large areas of exposed springwood. Where the growth rings are indistinct—as in southern temperate or tropical conifers—the wear is more even.

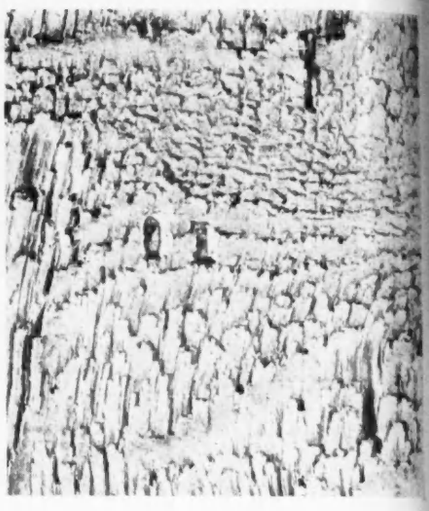
Resistance of wood to wear is not easy to evaluate. However, the Forest Products Research Laboratory, Princes Risborough, Aylesbury, Buckinghamshire, have developed an abrasion machine that simulates the conditions of service of timber floors. With it they have tested a large number of hardwoods and softwoods. *Timbers for Flooring*, by Mr. F. H. Armstrong gives an extensive review of the work. It is published by Her Majesty's Stationery Office, price 2*s.* 6*d.*

Abrasion by footwear is caused by the impact of heels and the scuffing of soles. The abrasion machine reproduces these motions. Two tools are used: a stamper with 12 cheese-headed studs, and a scuffer made up from a pad of wire-wound brake lining. The two are fitted to a planing machine, originally designed for metal, which gives the required rectilinear motion. A cam actuates the stamper, allowing it to fall freely from a fixed height, and a worm gear rotates the scuffer slowly under dead load.

Woods were tested in the form of blocks 9 in. long. They were prepared from a seasoned material with a moisture content of about 12 per cent. The load on the stamper was 30 lb.; it fell $\frac{7}{16}$ in. with 120 impacts a minute. A weight of 90 lb. was put on the scuffer and it rotated at 24 r.p.m. The reciprocating table moved at 22 ft. per minute. The test for hardwoods lasted a standard time of 100 hours. Softwoods wore more rapidly and were tested for only 30-50 hours.

Several tables of results are given. One tabulates timbers according to the way they wear—four ways are listed. Another gives the quantitative abrasion loss of various hardwoods. Hardwoods on the floor of a London Underground station showed the same types of wear as were produced in the machine, and so confirmed it to be a realistic test. It is interesting that, in the service tests, flat sawn maple—subjected to a traffic of 12,000 pedestrians per day for nine years—wore about 0·109 in. In the 100 hour laboratory test the same species wore about 0·054 in.

An appendix gives lists of timbers suitable for various types of floor. Some seventy timbers are considered. The recommendations for a decorative floor contain 20 species, ranging from afrormosia to yew, and including European oak, purpleheart, and panga panga. The last is also recommended as having small "movement" under conditions involving wide variations in temperature and humidity. So also is banga wanga, which can be used for exceptionally severe traffic, including trucking.



The abrasion machine has allowed comprehensive tables to be drawn up giving the wearing qualities of a wide variety of woods. Quartered oak, shown above, wears by cracking around the medullary rays.

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FRAMING TELEVISION

It might sometimes be worthwhile to provide the frame around a television screen with its own illumination. This conclusion was reached after a series of tests described in *Philips Technical Review* (vol. 19, No. 5, page 156, 1957). It was found that the frame width preferred on the average was 0·3 times the half-screen dimension—a value close to the customary widths of frames on modern television receivers. The preferred frame luminance was found to increase with the screen luminance as well as with the luminance of the surroundings. For modern sets in lighted rooms it appears that a frame luminance somewhere between 10 and 20 cd. per sq. m. would be preferred. A statistical analysis of the tests further demonstrated that the diverging wishes of the majority of viewers could be fulfilled by making the frame luminance variable between 0 and 40 cd. per sq. m.

The customary non-illuminated screen frames of domestic television sets derive their brightness from light reflected from the room and from the screen. Light-coloured frames might sometimes attain a luminance of 10 cd. per sq. m.; for a dull, fairly dark grey frame, 5 cd. per sq. m. is about the upper limit. As regards colour, the tests showed that observers unanimously preferred a frame the same colour as the picture.

TESTING KETTLES

Electric kettles have been scrutinised by the Association for Consumer Research Limited, 16 Victoria Park-square, London, E.2. Their method was to select ten branded kettles and to put each through the tests laid down by the British Standards Institution. Their results were published in the autumn edition of the magazine *Which*.

As the British Standard is a minimum specification, Consumer Research made some additional tests of their own. But the life test and the table-temperature test of the Standard were not carried out. The following points were examined: insulation and earthing—to check electrical safety; electrical loading—to ensure that the amount of electricity consumed was as specified; temperature measurement of the handling surfaces—to prevent burning; performance—to measure thermal efficiency; automatic safety device—to ensure that the current is disconnected if the kettle is switched on empty or allowed to boil dry.

The kettles selected were of the 3 to 3½ pint size: six of the aluminium type (costing about £3 10*s.* 6*d.* each) and four of the chromium-plated copper type (costing between £4 16*s.* and £6 6*s.* each).

At the end of the article describing the tests, Consumer Research place the kettles in the order of their choice. A chromium-plated copper kettle is placed first but it is not the most expensive one. Second comes a polished aluminium kettle. The only fault found with the first was that the wattage was not marked; otherwise it passed all tests—the only kettle to do so. The second was criticised because the lid gave a slight possibility of scalding and the spout had a rough finish; also the type number was not marked, which can be a disadvantage when spares are required.

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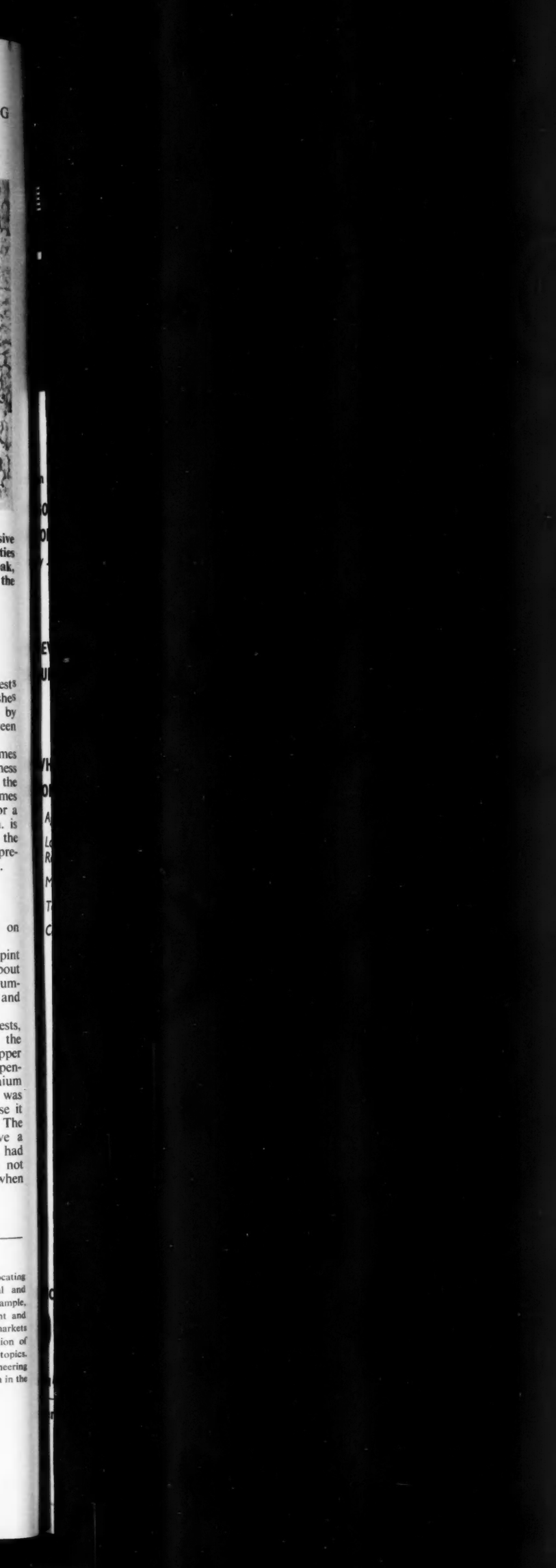
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